THE CANADIAN FIELD-NATURALIST

Volume 99

1985

THE OTTAWA FIELD-NATURALISTS' CLUB

OTTAWA CANADA

The CANADIAN FIELD-NATURALIST

Published by THE OTTAWA FIELD-NATURALISTS' CLUB, Ottawa, Canada

Volume 99, Number 1

January-March 1985

The Canadian Field-Naturalist

The Canadian Field-Naturalist is published quarterly by The Ottawa Field-Naturalists' Club. Opinions and ideas expressed in this journal do not necessarily reflect those of The Ottawa Field-Naturalists' Club or any other agency.

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Cover: Inflorescence of *Chamaepericlymenum canadense* showing some half dozen unopened flowers with the characteristic needle-like antennae which, when touched by an insect, result in a high speed "explosion" causing pollen to be deposited on the visiting insect. Photo courtesy of Mosquin Bio-Information Limited, Lanark, Ontario. See article by Theodore Mosquin, pp. 1–5.

The Canadian Field-Naturalist

Volume 99, Number 1 January-March 1985

The Explosive Pollination Mechanism in the Pop Flower, *Chamaepericlymenum* (Cornaceae)

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Mosquin, Theodore. 1985. The explosive pollination mechanism in the pop flower, *Chamaepericlymenum* (Cornaceae). Canadian Field-Naturalist 99(1): 1–5.

An explosive mechanism involving the entire pop flower of *Chamaepericlymenum canadense* (L.) Aschers. & Graebn. is described in detail. The only other species in the genus, *C. suecicum* (L.) Aschers. & Graebn., appears to possess an identical mechanism. The basic elements of the mechanism are: a sensitive antenna-like structure projecting from one petal of the unopened flower bud, reflexive petals, and stamen filaments possessing "elbow springs" which act to catapult the pollen in the anthers upwards toward the top of the flower. In comparison to all other "rapid movement" pollination mechanisms in the Angiosperms, this explosive mechanism is singularly unique. The presence of this unique mechanism has taxonomic implications for the question of the validity of the genus *Chamaepericlymenum* as an entity distinct from the genus *Cornus* in which the two species discussed have often been placed.

Key Words: *Chamaepericlymenum canadense*, Bunchberry, Pop Flower, *Cornus*, pollination.

Explosive or other rapid-movement floral mechanisms related to pollination are rare in the plant kingdom. In known examples where rapid movements do occur, it is the anthers or the stamens which move more or less alone or in consort with restraining petals. Examples described in the literature include the "explosive anthers" of *Pilea microphylla* Liebm. (Taylor 1942, p. 608), often referred to as the "artillery plant" and *Urtica* (H. G. Baker, personal correspondence) both members of the Urticaceae. Another example occurs in *Kalmia angustifolia* L. (Marie-Victorin 1942, p. 466) a member of the Ericaceae where the anthers are partially embedded in the petals and are simply released at maturity with the petals playing a stationary role. The examples of *Medicago* (alfalfa) and *Sarothamnus* (Scotch Broom) both in the Leguminosae have been widely reported in the literature (e.g. Meeuse 1961). In the genus *Lopezia* (Onagraceae) and in the genus *Hyptis* (Labiatae) the stamen, when touched, snaps upward and deposits pollen on the underside of an insect visiting the flower (P. Raven, personal correspondence). Some other examples brought to my attention by H. G. Baker (personal correspondence) are *Stylidium* (Stylidiaceae) *Mucuna* and *Ulex* (Leguminosae), *Odontonema* (Acanthaceae) and *Ravenala* (Musaceae). A number of less rapid floral movements related to pollination are described by Meeuse (1961).

The genus *Chamaepericlymenum* has only once been indicated to have an explosive floral mechanism (Marie-Victorin 1942). This genus contains two species, *C. canadense* (L.) Aschers. & Graebn, and *C. suecicum* (L.) Aschers. & Graebn. Both species are widely distributed in the northern hemisphere. *C. canadense* ranges across boreal North America and Eurasia, extending southward in mountainous areas of both land masses. *C. suecicum* occurs across Eurasia and in Greenland and Ungava. Both species are found in northern Japan.

Observations

I first learned about the pollination mechanism in *C. canadense* in 1968 while conducting observations and experiments on the reproductive biology of native plants in Banff National Park, Alberta. It was not until 10 years later that I was to find out that mine was not the first observation or recording of this explosive mechanism. The first and, to my knowledge, the only previous reference is contained in a one-line note by Marie-Victorin (1942) in Flore Laurentienne. In his flora he placed *Chamaepericlymenum* in the genus *Cornus*. In his description of *Cornus canadensis* L. he noted that "Les vrais pétales et les étamines sont élastiques et réagissent lorsqu'un insecte les touche." He did not record any observations on the "antenna" nor did he comment on the presence of a similar mecha-

FIGURE 1. Typical inflorescence of *Chamaepericlymenum canadense* showing the four white involucral bracts and about 25 individual flowers of which some six have not yet popped open. Photo courtesy Mosquin Bio-Information Limited.

nism in *Cornus suecicum* L. although the latter species was also included in his flora.

The inflorescence of *Chamaepericlymenum* is comprised of four white showy involucral bracts surrounding a few to several dozen small, relatively inconspicuous flowers (Figure 1). The true petals are a very light greenish yellow to nearly white in colour. The filaments and anthers are also very light coloured. However, the ovary, style and stigma are a very dark purple and provide striking miniature contrast points in the inflorescence. In the Banff area the number of flowers in each inflorescence varied from 8 to 15.

The pollination mechanism of *Chamaepericlymenum* is so intrinsically interesting as well as unique in the plant kingdom that I feel it would be worthwhile to record here a brief description of how the discovery was made. This account is based on plants growing near Altrude Creek about one mile south of Mt. Eisenhower Junction in Banff National Park.

Lying stomach down on the forest floor looking through a microscope, I began to examine the plants searching for a series of flowers in various stages of maturation. Normally, it is relatively easy to assemble such a sequence ranging from young buds to flowers that are very old and in a state of senescence. But each flower of *C. canadense* was either still in the bud stage or completely open with the petals very strongly reflexed outwardly or downward. In all open flowers the anthers extended upward, well above the tip of the stigma, and were empty of pollen. While the absence of flowers in the process of opening was puzzling, I attributed it at first to local environmental factors and continued to examine more inflorescences. The absence of pollen in the open flowers also seemed unusual but as the area was frequented by many species of pollen-feeding flies (Syrphidae), I speculated that perhaps the pollen had been collected by these colourful flower visitors.

Then with dissecting needles I began opening one of the buds, only to discover that it seemed to transform itself in a fraction of a second into a fully open flower. I turned to a second bud, opened it and found four normal-looking, fully developed, undehisced anthers. I tried a third and was again surprised by what appeared to be a tiny explosion and what seemed like a small amount of pollen flying in all directions. I

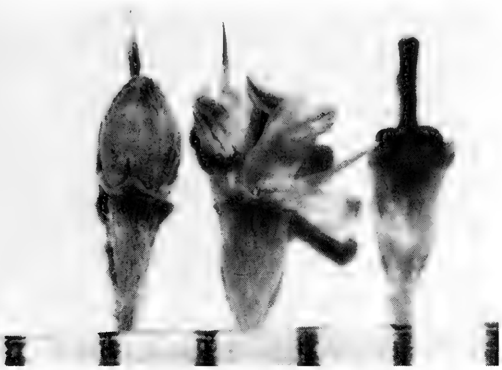

FIGURE 2. Photo of herbarium specimens of individual flowers of *Chamaepericlymenum canadense*. Left: unopened flower with characteristic antenna; centre: young flower opened apparently by pressure in a plant press showing the position of an antenna on one petal; right: more mature flower in which the petals and stamens have fallen off. The scale is in millimetres. Photo by T. Mosquin.

realized then that I might be looking at a unique phenomenon — perhaps never before witnessed by humans and perhaps undescribed.

It was then that I began to pay more attention to another unusual characteristic of each flower. On the abaxial side and near the tip of one of the four petals of each unopened flower and projecting upward was a miniature "antenna" just over 1 mm long (Figure 2). It did not take long to establish that even the slightest touch of the dissecting needle to the antenna of any "ready to pop" flower would trigger the explosive mechanism; the petals would reflex, the anthers would spring out simultaneously like four tiny catapults and shoot their entire pollen loads into the air above the inflorescence.

The mode of attachment of the anther to the filament, its position, and the timing of its development within the bud cast some light on the morphological basis for the popping action. In the young bud, that is, one that is not mature enough to be tripped by mechanical means, the four anthers are undehisced. As the bud matures, anthers dehisce fully while still in the bud (but do not release their pollen). Once dehiscence is complete the pop mechanism seems to become activated and the slightest touch to the antenna will cause the flower to burst open.

The attachment of the anther to the filament is basal but in the enclosed bud the anther itself is pointed downward so that in younger buds the attachment of the filament appears to be terminal. This means that the abaxial (outside) surface of each anther is appressed tightly against the upper part of the pistil. As the bud and the pollen mature, slits are formed on the abaxial surfaces of the anthers. At this stage both the reflexed tip of the filament as well as the petals come under a powerful tension which is released only when the pop mechanism is triggered. During the "popping" the arched tips of the filaments act as elbow springs and the four anthers snap upward. The "popping" of the flowers occurs so rapidly as to be scarcely perceived by the naked eye even through the microscope. After popping, the stamens assume a more or less vertical position and appear to be empty of pollen. Pollen grains are light yellow in colour and slightly sticky; they are too large and heavy to be carried away by the wind.

Discussion

The explosive mechanism in *Chamaepericlymenum* described here involves the extremely rapid simultaneous movement of both stamens and petals. As well it includes the participation of a needle-like "antenna". If the weather is sunny and dry and a flower is "ready to pop", then the slightest touch to the antenna produces an explosive opening of the flower that takes place so instantaneously that the human eye can scarcely perceive the occurrence.

Aside from the popping mechanism, which seems to be a device favouring cross pollination, little is known about the breeding system of plants of this genus. When a flower pops, some pollen is deposited on its own stigma so automatic self-pollination is possible. It would be interesting to find out whether an incompatibility system is associated with the popping mechanism.

While at Banff, I failed to record a single insect visitor on flowers of *Chamaepericlymenum*. However, Sadlier and Sadlier (1977, p. 100) published a photograph showing a wild species of the leafcutter bee genus, *Megachile*, visiting an inflorescence in which about two-thirds of the flowers had already popped. The leafcutter bees are known to be major collectors of pollen (Hobbs and Lilly 1954; Krombein 1967; Rank 1982) which they use in quantity to provision their nest cells. My observations of *Chamaepericlymenum* flowers showed a complete lack of nectar and it is likely that various *Megachile* species, which occur throughout the North American range of *Chamaepericlymenum* (Ivanochko 1980) are the principal pollinators. Pollen eating flies (Syrphidae) may also be effective pollinators. However, in view of the sensitivity of the antenna of any "ready to pop" flower, it would appear that even very small insects such as woodland midges could act as pollinators should they happen by chance to fly from one inflorescence to another. In view of the seeming force of the popping mechanism and the presence of the needle-like

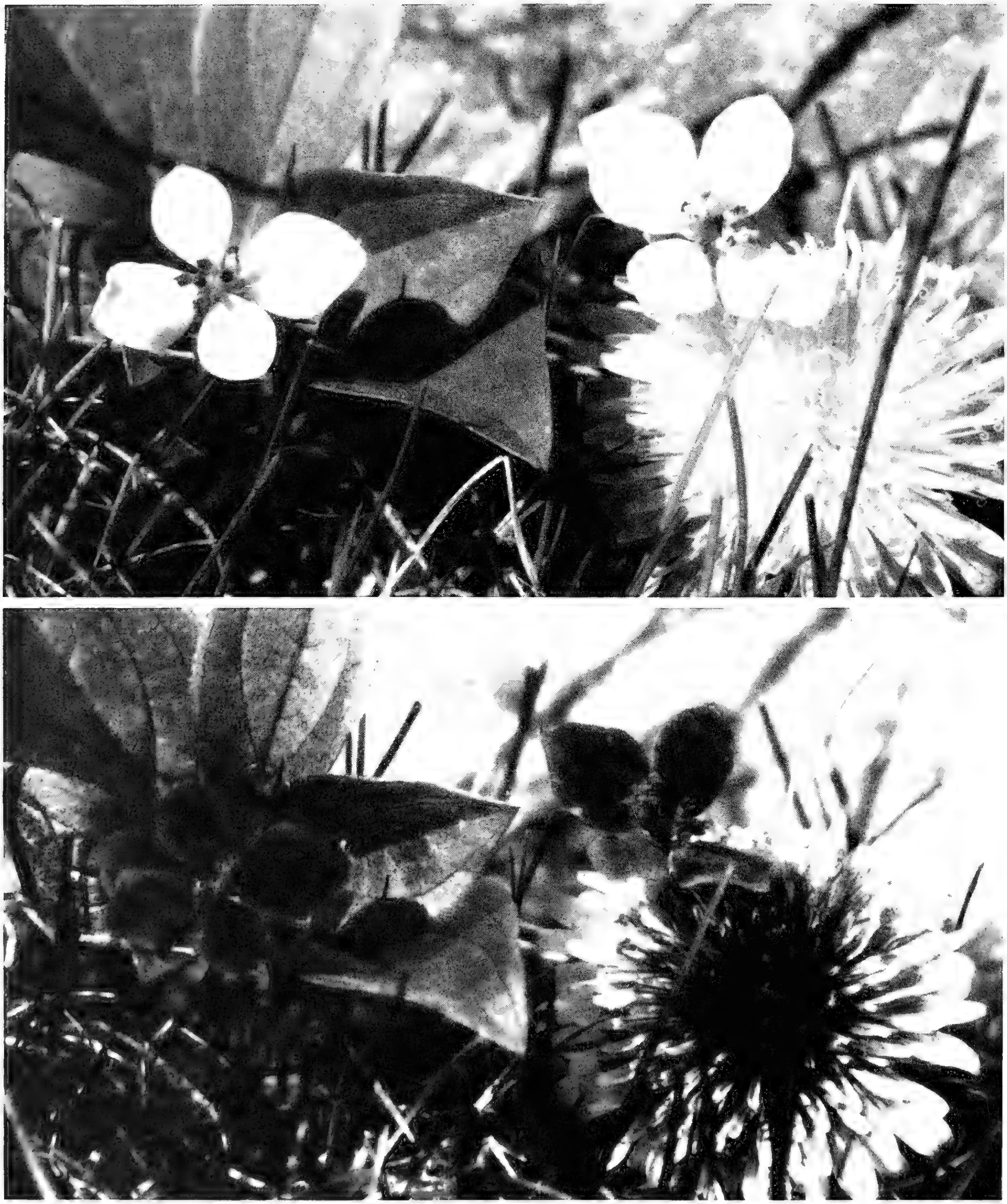

FIGURE 3. Above: *Chamaepericlymenum canadense*; photo taken in sunlight without filters using Kodak Tri-X film. Below: similar photo of same plants taken through quartz lens and a Kodak Wratten 18A filter which transmits only ultraviolet light and showing the degree of absorption of ultraviolet light rays by the four involucral bracts of each inflorescence. Flower at right is the Common Dandelion, *Taraxacum officinale* L. included for comparison. Photo by T. Mosquin.

antenna, it would be surprising if the fully mature buds did not pose some threat to life and limb of the smaller and more fragile of the woodland insects.

The colour of the involucral bracts of *Chamaepericlymenum* is white and it is known that the bracts strongly absorb ultraviolet light (Figure 3). This means that the higher groups of pollinating insects such as the bees would be able to distinguish the bracts from the adjacent and background objects quite clearly (Mazokhin-Porshnyakov 1969). Thus it is not the flowers but rather the involucral bracts which make it possible for bees to effect cross pollination.

The conclusion that *C. suecicum* has an explosive mechanism very similar to *C. canadense* is based upon examination of herbarium specimens at Agriculture Canada (DAO) and the National Museum of Natural Sciences (CAN). The flowers of these two species are essentially identical except that the floral parts of *C. suecicum*, including pistil, stamens, petals and the tiny sepals are all deep purple in colour.

An understanding of the reproductive biology of a taxonomic group will strengthen the foundation upon which taxonomic judgements are made (Ornduff 1969). In the past, *C. canadense* has frequently been lumped with the genus *Cornus* (Marie-Victorin 1942; Harrington 1954; Scoggan 1957; Moss 1959; Munz and Keck 1968), a north-temperate genus of shrubs and trees with some 45 species (Lawrence 1951). Some modern European floras do recognize *Chamaepericlymenum* as a genus (Shiskin 1951; Clapham et al. 1962) although all authors with the exception of Marie-Victorin (1942) were apparently unaware of the unique nature of the floral mechanism. The reproductive characteristics described in this paper provide strong added argument, I feel, for separate generic status for these two species.

To make certain that any species in the genus *Cornus* did not contain the antenna feature so characteristic of the pop flowers of *Chamaepericlymenum*, I examined petals of flowering specimens of all species of *Cornus* in the extensive herbarium collections at Agriculture Canada (DAO) and the National Museum of Natural Sciences (CAN) at Ottawa; all had petals with smooth abaxial surfaces; petals lacked any semblance of structures like the antennae of *Chamaepericlymenum*.

The widely used but mundane common name of *Chamaepericlymenum* is "Bunchberry." A much more interesting, meaningful and dynamic name would be "Pop Flower."

Acknowledgments

The work described above was done while the author was on staff of the Plant Research Institute, Department of Agriculture, Ottawa (now the Biosystematics Research Institute, Agriculture Canada). I am grateful to the Canadian Forestry Service for use of their accommodation facilities at the Mount Eisenhower Forest Research Station and to the curators of the herbaria at Agriculture Canada (DAO) and the National Museum of Natural Sciences (CAN) for permission to examine the specimens in their care.

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Received 30 December 1983
Accepted 17 August 1984

Home Range Size and Habitat Selection of Bobcats, *Lynx rufus*, in North-Central Montana

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A study of Bobcat (*Lynx rufus*) habitat selection and movements was conducted from January 1979 through August 1980 on the Charles M. Russell National Wildlife Refuge in north-central Montana. Five cats were radio-collared and followed from 2 weeks to 17 months with three of the cats accounting for 423 of the 457 relocations. Of these, home range size was largest (83.3 km²) for the adult male, followed by the adult female with 17.8 km² and her male kitten with 5.8 km². Nine cover types were designated on the study area and vertical vegetative cover was measured with a coverboard for each type. The juniper cover type was the densest (93% cover), followed by river bottom (75%), Douglas-fir (71%), dense pine (52%), greasewood (30%), open pine (24%), sage-grass (11%), agricultural (9%), and prairie dog town (3%). The three cats with over 50 relocations each all showed significant selection for cover types with 52% cover or greater. The only cover type with less than 52% cover used more often than expected was that of prairie dog towns. Lagomorph pellet transects showed a high positive correlation with cover type density. The highest densities of small rodents were in the dense cover types (greater than 50% cover) and the sage-grass cover type.

Key Words: Bobcat, *Lynx rufus*, home range, daily movements, habitat selection, Prairie Dogs, small rodents, lagomorphs.

Until recently, little was known concerning Bobcat (*Lynx rufus*) home range size and habitat use. Although several radio-telemetry studies have now been conducted on Bobcats, no published information exists concerning Bobcat home range size and habitat use in a northern prairie river breaks environment. This paper considers home range size and habitat use of Bobcats along the river breaks of the Missouri River in north-central Montana.

Study Area

The study area (440 km²) is located in north-central Montana (Figure 1) along the Missouri River at the northwest end of the Charles M. Russell National Wildlife Refuge and lies within the mid-grass prairies of the prairie biome. The area is an eroded plateau typified by rough timbered breaks and productive river-bottom lands. Elevation ranges from 680 m to 920 m. Officially the Refuge is closed to all hunting and/or trapping of Bobcats while the adjacent areas are open in accordance with State regulations.

Nine cover types were designated on the study area and are discussed in order of decreasing cover density. The juniper cover type was predominantly thickets of Rocky Mountain Juniper (*Juniperus scopulorum*) with few other conifers and little or no understory. The river bottom cover type occurred as parallel strips of vegetation along the River. Each strip was dominated either by Plains Cottonwoods (*Populus sargentii*) with a rose (*Rosa* spp.)-snowberry (*Symphoricarpus* spp.) understory, willows (*Salix* spp.) with no understory, or rose-snowberry with little understory. The Douglas-fir (*Pseudotsuga menziesii*) cover type had variable amounts of Ponderosa Pine (*Pinus ponderosa*) and juniper intermixed with the Douglas-fir and a patchy understory of rose, Chokecherry (*Prunus virginianus*), and snowberry. The dense pine cover type replaced the Douglas-fir cover type at the east end of the study area and had a similar understory. Greasewood (*Sarcobatus vermiculatus*) was found primarily in coulee bottoms and the upper edges of the floodplain of the River, and had a sparse grass-forb understory. The open pine cover type was found primarily on south-facing slopes and had an open canopy with a grass understory or sparse shrubs and bare ground on steeper slopes. The sage-grass cover type on the ridgetops was dominated by low growing stands of Big Sagebrush (*Artemisia tridentata*) and grasses such as Western Wheatgrass (*Agropyron smithii*) and Blue Grama (*Bouteloua gracilis*). Agricultural lands included parts or all of several river bottoms that were cultivated primarily for hay. Prairie dog towns differed from the sage-grass cover type in that grass was short, shrubs were absent, and the area was occupied by Black-Tailed Prairie Dogs (*Cynomys ludovicianus*). For more detailed information on the study area see Allen (1968) and Mackie (1970).

Methods and Materials

Bobcats were captured with No. 3 Victor longspring and No. 4 Montgomery coilspring leghold traps with offset jaws and 51cm × 38 cm × 106 cm livetraps from March through May 1979 and October 1979 through 15 February 1980. Captured cats were injected with ketamine hydrochloride (22 mg/kg) and xylazine (1 mg/kg), weighed, measured, radio-collared, eartagged, and sex and approximate age

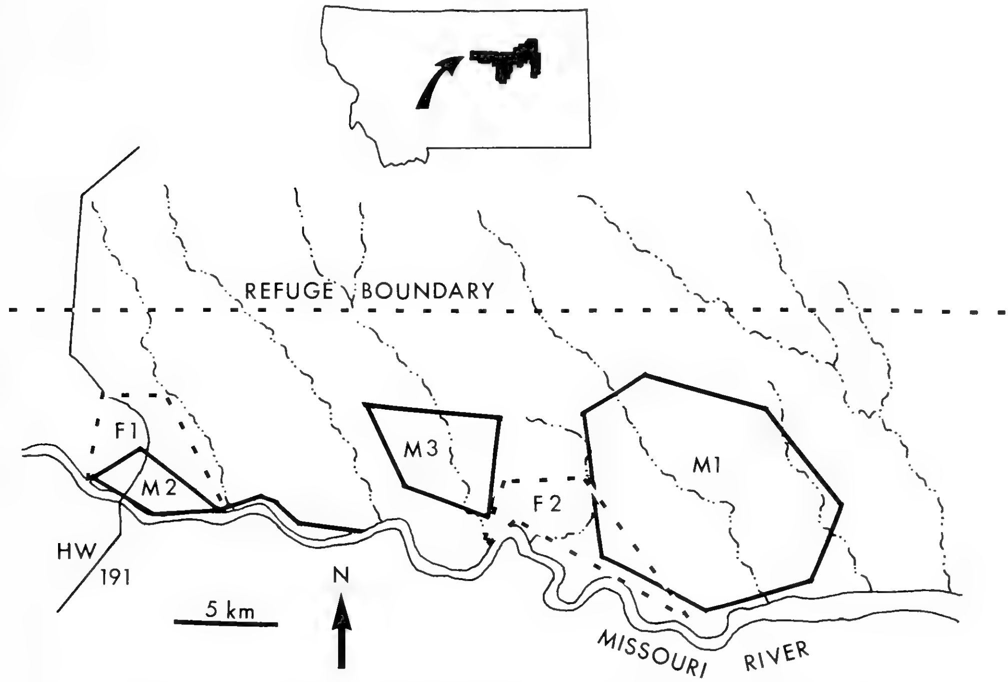

FIGURE 1. Map of the study area showing home ranges of five radio-marked Bobcats.

class determined. The collared cats were relocated until February 1980 when I left the study area. Additional relocations were made from June through mid-August 1980. Radio relocations were obtained primarily through ground reconnaissance, with 2% of the relocations obtained through aerial tracking with a Piper Supercub. Cover types within the home ranges of the Bobcats were mapped on acetate overlays on aerial photos (scale 1:24 000) and verified in the field. The area of each cover type was determined using an electronic digitizer. Selection of habitat was determined by comparing availability and use of cover types within the home range. Statistical significance of cover type selection was tested according to the method described by Neu et al. (1974). When determining seasonal use, seasons were designated as Spring (March-May), Summer (June-August), Fall (September-November), and Winter (December-February). Vertical vegetative cover in each of the cover types was quantified with a coverboard 2 m high, 1 dm wide, and marked at 1 dm intervals. The board was held vertically by an assistant 15 m from the observer, who recorded percentage of the board obscured by vegetation. Transects of five observation stations spaced 15 m apart with five corresponding board stations were used in each type sampled. The mean and 95% confidence limits were determined for each cover type.

I determined yearly and seasonal home range sizes using the minimum home range polygon method (Hayne 1949) or the modified minimum home range method (Harvey and Barbour 1965). Minimum daily movements were determined by measuring the distance in a straight line between relocations on successive days. Average daily movements by season were also calculated.

The assumption was made that cover type usage may be influenced by the relative abundance of small rodents and lagomorphs as these animals have been found to be important in the diet of Bobcats (Bailey 1979; Buttrey 1979; Kitchings and Story 1979). To determine the relative abundance of small rodents by cover type, 50 Sherman live traps were set in a grid (5×10 traps — 15 m intervals) for three nights in each cover type. The number of small rodents per 100 trap-nights was determined for each type. Relative lagomorph densities in the various cover types were sampled by counting fecal pellets within transects consisting of 10 randomly placed 0.2×0.5 m sampling frames. After establishing an initial point in a cover type, the direction and number of paces to the next frame were determined using a random numbers table.

All lagomorph pellets within each frame were counted regardless of age or condition. Three transects were placed in each cover type except in the river bottom and sage-grass cover types which only received one each. The mean and 95% confidence limits were determined for pellet densities in each type.

Results

Captured Bobcats

Trapping effort totalled 2091 trap-nights. Five Bobcats were captured seven times resulting in 299 trap-nights per capture, or 418 trap-nights per individual cat. All five cats were subsequently relocated and no trap-related injuries were noted. Cat F1, an adult female followed from 11 March 1979 through 2 August 1980, had two kittens in mid-May 1979, and a single kitten in June 1980. All kittens were observed at the den site soon after birth. An adult male, M1, was followed from 5 May 1979 through January 1980 when the external antenna on the collar broke off. Only two relocations were made after that time, one of which was a chance visual sighting in a prairie dog town on the last day of the study in August 1980. Cat M2, a male kitten of F1, was followed from 17 October 1979 through 30 December 1979 when he was illegally killed by hunters. Another juvenile male, M3, was caught on two December 1979 and was illegally killed by hunters in late January 1980. A juvenile female, F2, was captured on 30 January 1980 and radio contact was lost after 11 February 1980. There were other cats on the study area that were not captured despite trapping in those areas.

Seasonal and Annual Home Range Sizes and Movements

The home range size for F1 totalled 17.8 km². Seasonal home range size increased as the seasons progressed from spring through winter 1979 (Table 1). Summer 1980 home range size was almost twice as large as the summer 1979 home range size. The average daily movement of summer 1979 (0.4 km) was less than all other seasons (1-way ANOVA $P < 0.05$). In contrast, the average daily movement for the 1980 summer (1.6 km) was significantly greater ($P < 0.05$) than all other seasons except spring 1979. The home range size of M1 totalled 83.3 km². The seasonal home range size varied from 40.4 km² in the summer of 1979 to 61.8 km² in the winter. Daily movements averaged between 4.5 km in the winter and 5.5 km in the summer of 1979. No significant difference (Kruskal-Wallis 1-way ANOVA $P < 0.75$) was noted in the movements between seasons. The home range of M2 was 5.8 km². The modified minimum home range method was used for this cat because of his extensive use of the river bottom cover type and little use of upland types. M2 was occasionally found in upland types within his mother's (F1) home range, but never in an upland type outside of her home range. Therefore, those types were not included in the home range estimate for M2. The first three days after collaring M2 he was relocated in the immediate vicinity of his mother. Then for the following four days M2 and F1 were located in the same general area though not together at any time. After this period, M2 and F1 were never relocated together or even in the same general area although relocations were often made more than once a day and occasionally at night. Daily movements for M2 averaged 1.8 km. No seasonal data were available on this cat. Home range size estimates for M3 and F2 were 22 km² and 16 km² respectively, but these are based on only 12–16 relocations per cat.

Cover Types

The juniper cover type was the densest with 93% cover. This was followed by river bottom (75%), Douglas-Fir (71%), dense pine (52%), greasewood (30%), and open pine (24%). Sage-grass cover types were rarely over 0.5 m high and averaged 11% cover. Both agricultural lands and the prairie dog town cover types were primarily grass and/or forbs and had values of 9% and 3% respectively.

Habitat Selection

Sufficient numbers of daytime relocations were

TABLE 1. Seasonal home range sizes and movements of F1, M1, and M2.

	Number of Relocations			Home Range km²			$\bar{X}$ Daily Movement (km)		
Season	F1	M1	M2	F1	M1	M2	F1	M1	M2
Spring 1979	67	12	—	5.1	55.2	—	1.5	4.7	—
Summer	57	21	—	7.8	40.4	—	0.4	5.5	—
Fall	96	41	52	11.7	61.8	5.8	1.0	4.5	1.8
Winter	40	8	—	13.5	46.4	—	1.1	—	—
Summer 1980	27	2	—	13.0	—	—	1.6	—	—
Total	287	84	52	17.8	83.3	5.8	1.1	4.9	1.8

TABLE 2. Percent relocations and percent of home range ( ) in each cover type for F1, M1, and M2.

	Juniper	River Bottom	Douglas Fir	Dense Pine	Grease wood	Open Pine	Sage-Grass	Agri-culture	Prairie Dog Town
F1[a]	10(3)	28(2)	51(14)	—	0(16)	6(45)	1(19)	0(1)	4(tr)
M1[b]	46(7)	—	—	19(7)	2(10)	10(48)	0(26)	—	22(2)
M2[c]	—	90(27)	8(17)	—	0(34)	0(16)	1(2)	1(4)	—

[a]$x^2 = 2220.43$, $P < 0.005$. All observed proportions greater than 0 vary significantly ($P < 0.05$) from availability. *See* Neu et al. 1974.

[b]$x^2 = 209.78$, $P < 0.05$. All observed proportions greater than 0 vary significantly ($P < 0.10$) from availability. *See* Neu et al. 1974.

[c]$x^2 = 127.49$, $P < 0.05$. Observed proportions for river bottom and Douglas-fir vary significantly ($P < 0.10$) from availability. *See* Neu et al. 1974.

made for three of the five radio-collared cats (F1, M1, M2) to determine selection of cover types. Cover types were determined for 215 of 287 relocations of the adult female. Three cover types (Douglas-fir, juniper thicket, and river bottom) accounted for 89% of the relocations (Table 2). Douglas-fir and juniper types were consistently used during all seasons. River bottom was used in all seasons except spring when the bottomlands were inundated by flood waters of the Missouri River. The cat was also occasionally found at the only prairie dog town in her home range. The remaining cover types — open pine, sage-grass, greasewood, and agricultural, comprising 81% of the cat's home range — received little use throughout the study and accounted for only 7% of the relocations. Some seasonal trends in habitat use were evident. Douglas-fir and juniper were preferred during winter and spring while the river bottom received its greatest use in summer and fall. Use of the prairie dog town was not detected during spring and summer 1979, but it was used during the remainder of the study. Open pine was used more often during summer and fall 1979 than during the remaining seasons.

Cover type use was determined for 41 of 84 relocations for the adult male. He showed a strong selection for dense vegetative cover (Table 2). Dense pine and juniper comprised only 14% of his home range but accounted for almost 66% of the relocations. Although the prairie dog town cover type comprised only 2% of his home range, 22% of his relocations occurred on prairie dog towns and was the only open cover type frequently used. The remaining types (sage-grass, open pine, and greasewood) were all used much less often than would be expected. No relocations were made in the sage-grass type (26% of the home range) while open pine and greasewood both accounted for few relocations. Agricultural lands were absent from the home range of this cat. The sample size was too small to adequately determine seasonal trends, but use of the prairie dog town cover type increased during fall and winter. Use of the open pine type increased at the same time to a lesser extent.

Cover types for the male kitten (M2) were determined for 50 of 52 relocations. One cover type, river bottom lands (27% of the home range), accounted for 90% of the relocations (Table 2). All other cover types were infrequently used. Even though the river bottom cover type was intermixed with agricultural lands, this cat was found only once in the agricultural type.

Relative Small Mammal Densities

In 1979, trapping was conducted in 4 cover types (Table 3). The juniper cover type had the highest density of small rodents at 32 captures/100 trap-nights, followed by dense pine (17), Douglas-fir (16), and river bottom (14). In 1980, trapping was conducted in all 9 cover types and the highest density (9) was in the sage-grass type. River bottom and dense pine followed with 7 and 6, and juniper and Douglas-fir had 4. The remaining open cover types (less than 50% cover) had 3 captures/100 trap-nights or less.

The most numerous small rodent species during all years and in all types was the Deer Mouse (*Peromyscus maniculatus*). In 1979, however, voles (*Microtus pennsylvanicus* and *M. ochrogaster*) were also abundant based on trapping data and visual observa-

TABLE 3. Percent cover, and lagomorph pellet and small rodent densities in the nine cover types on the study area.

Cover Type	% Cover	Pellets/ Frame	Small Rodents/ 100 trap-nights 1979	1980
Juniper	93	13.2	32.0	4.0
River bottom	75	5.1	14.0	6.7
Douglas-fir	71	4.5	15.7	4.0
Dense Pine	52	4.8	17.3	6.0
Greasewood	30	1.8	—	2.0
Open Pine	24	1.2	—	3.3
Sage-Grass	11	0.4	—	8.7
Agricultural	9	0	—	1.3
Prairie Dog Town	3	0	—	2.7

tions. Yellow Pine Chipmunks (*Eutamias amoenus*) were frequently caught in all of the dense cover types in 1979. Other small rodents captured or observed on the study area included the Wyoming Pocket Mouse (*Perognathus fasciatus*), House Mouse (*Mus musculus*), Bushytail Woodrat (*Neotoma cinerea*), and Northern Pocket Gopher (*Thomomys talpoides*).

Mean values of lagomorph pellets for each cover type showed strong positive correlation to percent cover in each type ($r^2 = 0.802$, $P < 0.001$). No pellets were found along transects in agricultural or prairie dog town types. No attempt was made to identify pellets by species. White-tailed Jack-rabbits (*Lepus townsendii*) were usually seen in the sagebrush and prairie dog town cover types while cottontails (*Sylvilagus* spp.) were usually seen in river bottom, greasewood, open pine, and Douglas-fir cover types. Both *Sylvilagus audubonii* and *S. nuttalli* are found on the study area with the most common being *S. audubonii* (Trout 1978). Annual lagomorph population trends were determined from data collected by the Montana Department of Fish, Wildlife and Parks and suggest a decline in lagomorph densities from 1979 to 1980 with population peaks in 1977 and 1979 (Knowles 1981).

Discussion

Among the three cats (F1, M1, M2) that had over 50 relocations, the adult male (M1) clearly had the largest home range and average daily movements. The adult female (F1) used an area three times the home range size of her marked kitten (M2), but exhibited shorter average daily movements for the same time periods. This suggests that either the juvenile male traveled more extensively within his home range or that F1 returned to the same location more often. Little can be concluded about the other two cats (F2, M3) because of the limited period that each was followed. Their actual home ranges were probably larger than those recorded. F2's daily relocations were progressively farther away from the capture site and she may have been a dispersing individual.

Reported home range sizes of Bobcats in the literature differ widely. Home range size may be influenced by many factors including the field technique used, season and duration of the work, geographic region, the availability of prey, and sex, age, and density of Bobcats. In southern Alabama Bobcat home range sizes averaged 2.63 km^2 for males and 1.12 km^2 for females (Miller and Speake 1979). Berg (1979), in Minnesota, found home range sizes to average 62 km^2 for adult males and 38 km^2 for adult females. Bailey (1974) working in Idaho reported average home range size for males at 42.1 km^2 and females at 19.3 km^2. Although Bailey did not mention the seasons encompassed by these relocations, he did state that the transmitters lasted for approximately 3.5 months. Thus, the home range sizes for his cats may actually be larger than those he reported. Buie et al. (1979) in South Carolina reported home ranges averaging 20.78 km^2 for males and 10.35 km^2 for females during a six-month radio tracking study in the fall and winter seasons but found no significant difference in home range size between seasons. Hall and Newsom (1978) reported summer female and male home ranges at 0.98 and 4.9 km^2, respectively, in Louisiana. Marshall and Jenkins (1966) reported spring-summer female home ranges of 1.79 km^2 in South Carolina. These were considerably smaller than the average summer home range size of 7.8 km^2 for F1. In general, males tend to have larger home range sizes than females (Bailey 1974; Berg 1979; Buie et al. 1979; Miller and Speake 1979; and others). However, Zezulak and Schwab (1979) reported home range size did not correspond to sex where their data were adequate to make comparisons between sexes.

Variation in the seasonal home range size of F1 was due, at least in part, to reproductive constraints and changing prey abundance. Although she had smaller average daily movements during the summer when remaining close to the den, F1 moved her kittens at various times thereby increasing the summer home range size. Prey appeared to be abundant throughout the summer of 1979 and into the early fall. F1's home range size in the fall increased from the summer, possibly because of increased size of the kittens and their ability to travel on their own. The fact that M2 and F1 were no longer relocated in the same vicinity in the late fall and winter suggests that the kittens were not dependent on F1 for food during the winter months. However, because prey abundance had probably decreased by winter, F1 may have needed to hunt further distances to obtain enough food for her own maintenance. Summer home range size in 1980 was twice that of 1979. F1 had only one kitten in early June 1980 but I was unable to determine if it survived. Relative densities of small rodents and lagomorphs were lower in 1980 than the previous summer. F1 was probably forced to hunt more extensively over a larger area, whether she had a kitten or not. This may explain the larger average daily movements and home range size for summer 1980.

Habitat Selection

Because Bobcats originally occurred widely throughout North America, they are obviously adapted to a variety of habitats. Much of the literature describes Bobcat habitat as areas with rocky outcrops (Young 1958), but Rollings (1945) noted that where rock outcrops were not available the cats preferred areas with dense undergrowth. McCord (1974) con-

cluded in a study of winter habitat selection in Maine that Bobcats selected cover types with high prey densities combined with dense cover. However, he concluded that prey abundance and environmental conditions alone were not sufficient to explain the selection for the more dense cover types and that behavioral factors were important considerations. The hunting methods employed by Bobcats make some kind of cover important for hunting success. Therefore, Bobcats probably use rocky outcrops and dense vegetation in a similar manner, both as security cover and as an aid to their hunting techniques. The use of prairie dog towns are an exception in that they provide little vegetative and topographic cover. Bobcats relocated on prairie dog towns in this study were observed to hunt Prairie Dogs with a "sit and wait" strategy; lying behind clumps of vegetation or in drainage ways at town edges or on prairie dog mounds. This strategy appeared to be successful as on several occasions Bobcats were observed to catch or nearly catch prairie dogs. Such a hunting method required little energy expenditure on the part of the Bobcat and towns were easily located.

In this study, 74% of the combined relocations of M1, F1 and M2 were in dense cover types (greater than 52% cover) that made up less than 40% of their home ranges. These dense vegetative types coincided with high prey densities of lagomorphs and rodents. Thus, these cover types provided both food and the cover necessary for the cat's hunting technique. Berg (1979) found Bobcats to prefer areas of coniferous vegetation which comprised the principal habitat on a year-round basis for Snowshoe Hares (*Lepus americanus*), the main food item of Bobcats on his study area.

Seasonal variation in use of cover types occurred with F1 and, to a lesser degree, M1. Seasonal shifts in cover type usage may be accounted for by several factors. The minimal use of the river bottom cover type during the spring of 1979 by F1 was undoubtedly due to flooding. F1 and M1 were not found in the prairie dog town cover type during the summer of 1979 but use increased during the fall and winter months for both F1 (6% of the relocations) and particularly M1 (33% of the relocations). A possible explanation is that the decline in the small rodent population from 1979 to 1980 began during the fall of 1979. At the same time, Prairie Dogs remained active throughout the fall and winter foraging above ground during sunny weather and provided an alternative prey source. Use of the Douglas-fir and juniper cover types by F1 also increased during the winter concurrent with a decreased use of the river bottom cover type. Because snow was scarce during the winter of 1979–1980, snow cover was not a factor influencing choice of cover types. However, the river bottom cover type was primarily deciduous and once leaves dropped cover density decreased, and dried leaves probably decreased the ability to hunt silently. In contrast, the Douglas-fir and juniper cover types were primarily coniferous with little deciduous understory. The increased use of prairie dog towns by F1 during summer 1980 compared to summer 1979 (20% versus 0% of the relocations) is probably explained by the substantial decline in small rodent and lagomorph densities from 1979 to 1980. The 1980 den of F1 was also located within 1 km of a prairie dog town which provided a readily accessible food supply.

Acknowledgments

Support for this study was provided by Montana Cooperative Wildlife Research Unit, Charles M. Russell National Wildlife Refuge, U.S. Forest Service, and Sigma Xi. I thank B. O'Gara for technical advice and assistance throughout the study, and J. Ball, C. Jonkel, L. Metzgar, and B. O'Gara for providing critical review of an earlier version of the manuscript. The following people provided field assistance: D. Fortenberry, K. Hamlin, W. Kent, C. Knowles, D. Meek, S. Olson, C. Stoner, and C. Swick.

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Received 3 May 1983
Accepted 1 August 1984

Responses of Small Mammals to Forest Harvesting in Northern Maine

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Comparisons between relative abundance of small mammals in harvested and uncut softwood and hardwood stands were made between 1975 and 1977 in northern Maine. Twelve softwood clearcuts representing three successional stages (slash, *Rubus*, sapling), two partially cut stands, and four uncut stands were snap-and-pit trapped for 60 279 trap nights. The total small mammal community increased following harvesting in softwood stands. Red-backed Voles (*Clethrionomys gapperi*) were more common in slash and sapling stages and partially cut softwoods than in uncut softwoods. Deer Mice (*Peromyscus maniculatus*) were more abundant in uncut and partially cut softwoods than in *Rubus* or sapling stages. Meadow Voles (*Microtus pennsylvanicus*) preferred partially cut softwoods and the *Rubus* stage compared to uncut softwoods. Masked Shrews (*Sorex cinereus*), Smoky Shrews (*Sorex fumeus*), and Pygmy Shrews (*Microsorex hoyi*) were collectively more common in harvested stands than in uncut softwoods or hardwoods.

Key Words: clearcutting, small mammals, northern Maine.

Effects of forest harvesting on small mammals in northern forests have received relatively little attention by researchers. Martell and Radvanyi (1977) and Sullivan (1979) reviewed some of the previous studies. Few studies have been conducted on responses of small mammals to forest harvesting in Maine. The objective of this study was to compare the relative abundance of small mammals in clearcut, partially cut, and uncut forests.

Study Area

The study area was located near the east shore of Moosehead Lake in T1R14 WELS and East Middlesex Canal Grant Townships, Piscataquis County. The area lies in the Spruce-Fir-Northern Hardwoods Zone (Westveld et al. 1956). Conifer forests are dominated by Red Spruce (*Picea rubens*) and Balsam Fir (*Abies balsamea*), and hardwood forests by Sugar Maple (*Acer saccharum*), American Beech (*Fagus grandifolia*), and Yellow Birch (*Betula alleghaniensis*).

Forest harvesting produced a mosaic of vegetation within the conifer and hardwood forests.

Conifer Forest

Uncut — Uncut softwoods consisted of stands of Balsam Fir and Red Spruce averaging 24.8 to 43 m²/ha basal area and 85–90% canopy density (Soutiere 1979). Ground covers were relatively scarce consisting of saplings (predominantly Balsam Fir and Red Spruce), rotting logs, and other woody debris. Average density of saplings (> 30.5 cm tall and < 8.9 cm dbh), determined from sixty 4 m² plots/sample stand, was 1.2/m² (0.5–2/m²). Raspberry (*Rubus sp.*) stems were absent from uncut stands in contrast to all other study areas (based on sixty 0.5 m² plots/sample stand). Plants that occurred most frequently on the 0.5 m² plots included Common Wood Sorrel (*Oxalis montana*), ferns (Pteridophyta), Bunchberry (*Cornus canadensis*), Wild-Lily-of-the-Valley (*Maianthemum canadense*), and trillium (*Trillium sp.*)

Partially Cut — Partially cut stands were harvested to minimum diameter limits of 15 cm dbh for Balsam Fir and 40 cm for Red Spruce. Average basal area of the sample stand was 22.3 m²/ha, representing a 52% reduction compared to mature uncut softwoods. Canopy density averaged 48%. Logging slash was present but less concentrated than in clearcuts. Average densities of sapling and *Rubus* stems were 0.02 and 2.1/m², respectively. Ground vegetation was sparse. Common plants were Wild-Lily-of-the-Valley, Common Wood Sorrel, Bunchberry, ferns, Indian Cucumber-root (*Medeola virginiana*), Goldthread (*Coptis trifolia*), and violets (*Viola sp.*).

Clearcut/Slash — Recent (1–3 years after cutting) clearcuts were dominated by dense logging slash (Figure 1). Herbaceous vegetation was sparse and appeared desiccated due to drying caused by canopy removal. Mean densities of sapling and *Rubus* stems were 0.04/m² (0–0.1/m²) and 7.1/m² (2.7–11.6/m²), respectively. Dominant herbs were fireweed (*Epilobium sp.*), Common Wood Sorrel, and ferns.

Clearcut/Rubus — Stems of *Rubus* dominated the intermediate successional stage (4–8 years after cutting) of clearcuts (Figure 2). The mean stem density of *Rubus* was 40.1/m² (29.1–49.1/m²). Logging slash had undergone some decay, but was still abundant beneath the *Rubus* cover. Saplings were scattered

FIGURE 1. Clearcut/slash successional stage with dense accumulation of logging debris. Each division on board equals 30.5 cm.

FIGURE 2. Clearcut/*Rubus* successional stage with dense *Rubus* stem cover and scattered saplings.

with densities averaging 2.8/m² (1.3–5.3/m²). Graminoids and other herbaceous plants were abundant in localized wet areas, but generally scarce beneath the dense *Rubus* cover.

Clearcut/Sapling — The older (9–18 years after cutting) stage of clearcuts was dominated by saplings with more uniform canopy density (Figure 3). The mean density of saplings was 5.3/m² (3.4–6.9/m²). Predominant saplings included Pin Cherry (*Prunus pensylvanica*), Paper Birch (*Betula papyrifera*), Yellow Birch, Striped Maple (*Acer pensylvanicum*), Mountain Maple (*Acer spicatum*), and Red Maple (*Acer rubrum*) in addition to Balsam Fir and Red Spruce. Ground covers were reduced compared to the *Rubus* stage due to the decay of slash and reduction of intolerant *Rubus* stems. *Rubus* stem density averaged 17.7/m² (13.9–38.8/m²). Common plants included mosses (Bryophyta), Common Wood Sorrel, Wild-Lily-of-the-Valley, Bunchberry, ferns, and Starflower (*Trientalis borealis*).

Hardwood Forest

Uncut — Uncut hardwoods consisted of mature stands dominated by Sugar Maple, American Beech, and Yellow Birch. Average basal area was 34.9 m²/ha and mean canopy density was 45.5%. Stem densities of saplings and *Rubus* averaged 1.9 and 1.8/m², respectively. Other ground covers were generally sparse consisting primarily of deadfalls and occasional areas of dense herbaceous growth under canopy openings. Seedlings of Sugar Maple, Striped Maple, American Beech, and Yellow Birch were the most frequent plants recorded on 0.5 m² plots.

Partially cut — Partially cut stands were harvested to minimum diameter limits of 40 cm. Average basal area of the sample stand was reduced 29% compared to uncut hardwoods. Canopy density averaged 31.9%, representing a 30% decline compared to uncut stands. Sapling (predominantly *Acer* sp.) and *Rubus* stem densities averaged 0.9 and 0.1/m², respectively. Additional ground covers consisted of scattered logging debris and deadfalls. Violets, Indian Cucumber-root, Starflower, ferns, and Wild-Lily-of-the-Valley were common plants.

Methods

Snap-and-pit trapping was conducted in twelve clearcuts (two slash, six *Rubus*, four sapling) in softwood stands, four uncut stands (three softwood, one hardwood), and two partially cut stands (one softwood, and one hardwood) for 3 successive nights during two-or-more periods between 1975 and 1977.

FIGURE 3. Clearcut/sapling successional stage with more uniform canopy density of saplings and reduced *Rubus* stem cover.

Seven clearcut, two partially cut, and two uncut study areas were established in 1975 and the remaining in 1976. Trapping periods were in July and October, 1975 and 1976, and in July, 1977. Total trap nights were 60 279. Trapping grids were 10 × 10 stations with 10 m between lines and stations. Two Victor mouse traps, baited with peanut butter, were placed within 1 m of each trap station. Pit traps consisted of number 10 cans buried flush with the soil surface and partially filled with water. One pit trap was placed at every third station to trap shrews which are often undersampled by snap traps (Pucek 1969). Grids in clearcuts were centrally located to reduce immigration into grids from adjacent forested areas. Abundance (use or activity) data were analyzed by Chi-square methods with a correction for continuity (Zar 1974). Data were pooled for the three years overall.

Results

The relative abundance of small mammals and trapping effort within the various habitats are shown in Table 1. Red-backed Voles (*Clethrionomys gapperi*), Deer Mice (*Peromyscus maniculatus*), Meadow Voles (*Microtus pennsylvanicus*), Masked Shrews (*Sorex cinereus*), Smoky Shrews (*Sorex fumeus*), and Pygmy Shrews (*Microsorex hoyi*) comprised 93.4% of the total catch. Overall small mammal use was greater in partially cut and clearcut softwoods than in uncut softwoods, and greater in partially cut softwoods than in the slash stage of clearcuts (Table 2). The slash stage received less use by the small mammal community than *Rubus* or sapling stages of clearcuts. Small mammal activity was greater in uncut hardwoods than in uncut softwoods or the slash stage, and lesser in uncut hardwoods than in partially cut softwoods. Relatively more small mammals were caught in partially cut hardwoods than in uncut softwoods, the slash stage, or *Rubus* stage.

Red-backed Voles were more common in the slash stage, sapling stage, and partially cut softwoods than in uncut softwoods (Table 2). Partially cut and uncut softwoods received greater use by Red-backed Voles than the *Rubus* stage. The sapling stage was used more than slash or *Rubus* stages, and the slash stage more than the *Rubus* stage. Activity was greater in uncut hardwoods than in the *Rubus* stage, and lesser in uncut hardwoods than in partially cut softwoods or the sapling stage. Partially cut hardwoods were used more than the *Rubus* stage, and less than the sapling stage.

Deer Mice used uncut and partially cut softwoods more than *Rubus* or sapling stages, and the slash stage more than the *Rubus* stage (Table 2). Use of uncut and partially cut hardwoods was greater than in the three stages of clearcuts. Activity was greater in partially cut hardwoods than in uncut softwoods.

Meadow Voles preferred partially cut softwoods and the *Rubus* stage compared to uncut softwoods (Table 2). The sapling stage was used less than uncut softwoods, and partially cut softwoods more than slash or sapling stages. Meadow Vole activity was greater in the *Rubus* stage than in slash or sapling stages, and uncut or partially cut hardwoods. Relatively more Meadow Voles were trapped in partially cut softwoods than in uncut or partially cut hardwoods. Use of partially cut hardwoods was greater than in the sapling stage.

Abundance data for Masked Shrews, Smoky

TABLE 1. Relative abundance (mean catch/100 trap nights) of small mammals in uncut, partially cut, and clearcut stands in northern Maine between 1975 and 1977.

	Softwood					Hardwood	
			Clearcut				
Taxa	Uncut	Partially cut	Slash	*Rubus*	Sapling	Uncut	Partially cut
Clethrionomys gapperi	2.14 (0.54)[a]	3.00 (1.31)	2.73 (1.19)	1.55 (0.33)	3.74 (0.83)	2.22 (0.64)	2.21 (0.90)
Peromyscus maniculatus	1.25 (0.19)	1.53 (0.62)	1.16 (0.22)	0.86 (0.18)	0.89 (0.14)	1.65 (0.42)	2.18 (0.66)
Microtus pennsylvanicus	0.19 (0.16)	1.30 (0.67)	0.10 (0.10)	1.59 (0.74)	0.04 (0.02)	0.09 (0.07)	0.15 (0.11)
Sorex/Microsorex[b]	0.48 (0.31)	1.97 (1.00)	0.85 (0.46)	1.27 (0.37)	1.29 (0.40)	1.15 (0.73)	1.92 (1.18)
Blarina brevicauda	0.06 (0.05)	0.09 (0.06)	0.06 (0.06)	0.33 (0.13)	0.15 (0.05)	0.73 (0.61)	0.35 (0.28)
Zapus hudsonius	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.21 (0.13)	0.01 (0.01)	0.0 (0.0)	0.0 (0.0)
Napaeozapus insignis	0.01 (0.01)	0.0 (0.0)	0.0 (0.0)	0.06 (0.02)	0.10 (0.03)	0.16 (0.10)	0.18 (0.06)
Synaptomys cooperi	0.01 (0.01)	0.0 (0.0)	0.0 (0.0)	0.02 (0.01)	0.02 (0.01)	0.0 (0.0)	0.0 (0.0)
Sorex palustris	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.01 (0.01)	0.0 (0.0)	0.0 (0.0)
Sorex dispar	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.01 (0.01)	0.0 (0.0)	0.0 (0.0)
Condylura cristata	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.01 (0.01)	0.0 (0.0)	0.0 (0.0)
All species	4.14 (1.13)	7.89 (2.53)	4.90 (1.73)	5.89 (1.37)	6.27 (1.26)	6.00 (1.72)	6.99 (2.10)
Total trap nights	8 490	3 396	6 792	19 527	14 433	4 245	3 396

[a]Standard error in parentheses.
[b]Predominantly *Sorex cinereus*, but also includes *Sorex fumeus* and *Microsorex hoyi*.

TABLE 2. Chi-square analyses of differences between relative abundance of small mammals in harvested and uncut stands in northern Maine.

Comparisons	All species	*Clethrionomys gapperi*	*Peromyscus maniculatus*	*Microtus pennsylvanicus*	*Sorex/Microsorex*	*Blarina brevicauda*	*Zapus hudsonius*	*Napaeozapus insignis*
Softwood/softwood								
Uncut/partially cut	64.75***	7.11**	1.23	56.63***	57.49***	0.03	0.00	0.22
Uncut/slash	4.63*	5.07*	0.16	1.34	7.48**	0.11	0.00	0.01
Uncut/*Rubus*	32.66***	11.87***	8.73**	97.53***	35.95***	16.28***	15.62***	1.80
Uncut/sapling	42.55***	42.55***	6.55*	12.09***	35.76***	3.21	0.12	4.69*
Partially cut/slash	5.85*	0.73	2.38	63.28***	23.07***	0.03	0.00	0.00
Partially cut/*Rubus*	0.09	32.47***	12.20***	1.53	9.95**	5.08*	5.79*	0.94
Partially cut/sapling	0.60	3.82	10.80***	155.23***	8.51**	0.40	0.05	1.94
Slash/*Rubus*	9.17**	35.78***	4.30*	91.33***	7.69**	13.31***	12.31***	2.63
Slash/sapling	14.77***	13.71***	3.36	2.71	7.97**	2.56	0.04	7.66**
Rubus/sapling	2.25	160.33***	0.04	212.73***	0.03	9.39**	22.14***	0.90
Hardwood/hardwood								
Uncut/partially cut	2.58	0.00	2.55	0.11	6.80**	4.10*	0.00	0.02
Hardwood/softwood								
Uncut/uncut	14.86***	0.10	3.35	1.00	17.95***	43.43***	0.00	8.42**
Uncut/partially cut	9.68**	4.36*	0.11	41.17***	7.80**	16.03***	0.00	3.94*
Uncut/slash	5.85*	2.52	4.15*	0.03	2.36	34.85***	0.00	8.71**
Uncut/*Rubus*	0.09	8.43**	7.94**	58.01***	0.31	12.81***	7.40**	4.10*
Uncut/sapling	0.60	23.44**	16.44***	1.22	0.40	35.66***	0.00	1.02
Partially cut/uncut	38.85***	0.00	13.16***	0.06	55.42***	12.49***	0.00	8.59**
Partially cut/partially cut	1.78	3.82	3.50	29.47***	0.01	4.27*	0.00	4.17*
Partially cut/slash	18.85**	1.84	15.04***	0.11	20.97***	10.87**	0.00	9.34**
Partially cut/*Rubus*	6.00*	6.70**	44.85***	43.02***	8.37**	0.00	5.74*	4.01*
Partially cut/sapling	2.21	18.08***	39.61***	4.39*	7.13**	4.75*	0.05	1.23

* $P < 0.05$.
** $P < 0.01$.
*** $P < 0.001$.

Shrews, and Pygmy Shrews were pooled due to the difficulty in distinguishing between some specimens. However, Masked Shrews were predominant, comprising 88.6% of the positively identified individuals. These shrews were more abundant in partially cut softwoods and the three stages of clearcuts than in uncut softwoods (Table 2). Activity was greater in partially cut softwoods than in the three successional stages, and greater in *Rubus* and sapling stages than in the slash stage. Partially cut hardwoods were used more than uncut hardwoods, and uncut hardwoods more than uncut softwoods. Activity was greater in partially cut softwoods than in uncut hardwoods, and greater in partially cut hardwoods than in the three stages of clearcuts and uncut softwoods.

Short-tailed Shrews were trapped more frequently in the *Rubus* stage than in uncut or partially cut softwoods (Table 2). The *Rubus* stage was used more than slash or sapling stages, and uncut hardwoods more than partially cut hardwoods. Activity was greater in uncut hardwoods than in all softwood habitat types, and greater in partially cut hardwoods than in all softwood types except the *Rubus* stage.

Meadow Jumping Mice (*Zapus hudsonius*) were more common in the *Rubus* stage than in all uncut or partially cut stands, the slash stage, and the sapling stage (Table 2). The Woodland Jumping Mouse (*Napaeozapus insignis*) was more abundant in the sapling stage than in uncut softwoods or the slash stage. Uncut and partially cut hardwoods were used more by the Woodland Jumping Mouse than all softwood types except the sapling stage.

Abundance data were too limited to permit meaningful analyses of minor species including the Star-nosed Mole (*Condylura cristata*), Southern Bog Lemming (*Synaptomys cooperi*), Long-tailed Shrew (*Sorex dispar*), and Water Shrew (*Sorex palustris*). The lone specimen of Long-tailed Shrew was caught in the sapling stage which lacked rocky areas, the normal habitat for this species (Richmond and Grimm 1950).

Discussion

Greater catches of small mammals in partially cut and clearcut stands than in uncut forests may have related to greater ground covers and potential food

(Lovejoy 1975) available in harvested areas. Kirkland (1977) previously reported an increase in the small mammal community following clearcutting, although other studies have found changes in species composition rather than overall density of small mammals (Lovejoy 1975; Martell and Radvanyi 1977). The greater abundance of Red-backed Voles in slash and sapling stages than in uncut softwoods supported findings by Kirkland (1977), who believed his results were noteworthy in view of the normal preferences for forest habitat exhibited by this species. Varying results, however, were indicated in the *Rubus* vs. uncut softwoods comparison in our study. Greater catches of Red-backed Voles in slash and sapling stages than in the *Rubus* stage may relate to known affinities of this species for woody ground debris (Gunderson 1959; Miller and Getz 1972, 1973) and low, evergreen cover (Miller and Getz 1972, 1973), the latter often predominating in the sapling stage.

The greater relative abundance of Deer Mice in uncut softwoods than in *Rubus* and sapling stages differed from previous findings (Kirkland 1977; Martell and Radvanyi 1977; Sullivan 1979). Deer Mice, however, are known to be adaptable to diverse habitat types (Miller and Getz 1977). Greater numbers of Meadow Voles and Meadow Jumping Mice in the *Rubus* stage than in slash or sapling stages was probably due to their abundance in one moist area with dense, grassy cover. Meadow Voles are known to benefit from increased herbaceous growth following clearcutting (Kirkland 1977), and dense, herbaceous growth is preferred habitat of Meadow Jumping Mice (Brower and Cade 1966). Dry sites dominated by *Rubus* stems were seldom used by both species.

Probable increases in invertebrate food following clearcutting (Lovejoy 1975) may have accounted for greater catches of Masked, Smoky, and Pygmy Shrews in clearcut and partially cut areas than in uncut forests. Other studies have reported higher catches of Masked Shrews in clearcut than in uncut forests (Kirkland 1977; Martell and Radvanyi 1977). However, relatively more Short-tailed Shrews were trapped in uncut hardwoods than in all other habitats, indicating little apparent response by this insectivore to probable increases in invertebrate food following timber harvesting.

The greater abundance of Woodland Jumping Mice in the sapling stage compared to the slash stage or uncut softwoods may relate to their preference for dense shrub cover (Brower and Cade 1966).

Acknowledgments

We are grateful for the assistance of L. Avery, B. Burgason, J. Dykstra, B. Rand, and T. Stone who aided in data collection. M. Coulter and J. Gilbert of the School of Forest Resources at the University of Maine-Orono, and B. Blum and H. Crawford of the USDA Forest Service provided valuable assistance and encouragement throughout the study. This study was supported by funds provided by the USDA Forest Service, Northeastern Forest Experiment Station — Research Work Unit NE-1101.

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Received 3 September 1982
Revised 14 January 1984
Accepted 23 July 1984

Status of Colonial Waterbirds Nesting in Southern Manitoba

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The southern Manitoba nesting abundance, colony location, historic and present regional and provincial status of 12 colonial nesting waterbird species have been assembled, with major field data collected in 1979. American White Pelican (*Pelecanus erythrorhynchos*), Double-crested Cormorant (*Phalacrorax auritus*), and Ring-billed Gull (*Larus delawarensis*) breeding populations were at or near historic peaks with cormorant and pelican numbers larger than recent estimates for all of Canada. Eared Grebe (*Podiceps nigricollis*), and Western Grebe (*Aechmophorus occidentalis*) populations were considered in decline as were Common Tern (*Sterna hirundo*) and Caspian Tern (*Sterna caspia*) numbers. Management should include stronger protective measures, public education, colony habitat management, and monitoring of known and suspected colony locations. Human encroachment, pesticides, marsh draining, water-level manipulation, and disturbance are major threats to all Manitoba waterbird species.

Key Words: colonial nesting birds, Manitoba, colonies, habitat, status.

Southern Manitoba has a number of large, shallow lakes with numerous isolated islands, large fish concentrations, and sizeable marshes, ideal habitat for colonial nesting waterbirds. Large-sized lakes, a lack of human interest, and physical access problems such as dangerous reefs and rough water, as well as the short breeding season, all contributed to information shortfalls on the numbers and status of Manitoba's colonial nesting waterbirds.

Historic data concerning these birds have not been consistent. Just prior to 1900 there was an emphasis on species lists and population surveys (Thompson 1891). In that period, Lake Winnipegosis was recognized for its cormorant colonies, Shoal Lake and the Waterhen marshes for various colonial waterbirds (especially grebes), and the southern marshes of Lakes Winnipeg and Manitoba for gulls, terns and grebes. Newspaper accounts from southwestern Manitoba, compiled for the Provincial Wildlife Branch by people employed under the Federal NEED program in 1984, indicated that in 1885-1910 terns and gulls were common, the American White Pelican (*Pelecanus erythrorhynchos*) was a treasured bird for hunters, and the sighting of a cormorant was newsworthy.

During the 1920s and 1930s interest was rekindled, especially for uncommon species and for pelicans and cormorants (Mendall 1936; F. J. Rogers. 1935. Special Detachment, Southern Lake Winnipeg. Manitoba Provincial Government Wildlife Unpublished Files. Winnipeg. 27 pp.). In the mid-1940s to mid-1950s, commercial fishermen's concerns for fish stocks, considered threatened by cormorants, brought about Provincial studies and programs to reduce cormorant populations on Lake Winnipegosis (McLeod and Bondar 1953). Data on a number of cormorant colonies, with some comment on other species, were recorded during that period.

The mercury threat, pesticide residue scare, and concern for rare and endangered species led to a number of colonial nesting waterbird studies and surveys in southern Manitoba, sponsored by the Canadian Wildlife Service in the late 1960s and early 1970s.

Federal protection of gulls, terns, grebes and herons took effect in 1916 upon passage of the Migratory Birds Treaty between the United States and Canada. The pelican and Double-crested Cormorant (*Phalacrocorax auritus*) were not officially protected in Manitoba until 1963, when they received provincial protection under Division 6 of The Wildlife Act. The province still is pressured by trout farmers and commercial fishermen to control cormorant numbers, but no action has been taken.

There are several management concerns: 1) As habitat and nesting space are limited, species on the increase are adversely affecting other species; 2) Controls and artificial manipulation of Manitoba's major lakes for hydro-electric power production have upset natural conditions; 3) Human use of land (for gravel, marsh drainage, beaches, cottage development, island camping) is eliminating habitat; 4) Pesticides and other forms of pollution are continual threats; 5) Human disturbance is escalating as people in boats and all-terrain vehicles visit colonies; 6) Commercial fishermen and trout farmers feel threatened by increases of some fish-eating birds; 7) Information on numbers, colony locations or status is lacking for several species.

To help manage and protect colonial nesting water-

birds a survey was undertaken to determine colony locations and numbers of each species. Historic data were compared with these baseline data. Future monitoring of key colonies or species should allow managers to identify species or colonies of significance or in decline. The intent of this article is to document colony locations, estimate the present breeding populations, and evaluate the status of 12 species.

Methods

Colony and nest information from the literature, plus field data, were recorded on 1:250 000 topographic maps, which are on permanent deposit with the Manitoba Museum of Man and Nature, Winnipeg.

Field work included 21 hours of flying in a Cessna 185 aircraft with two observers over all major Manitoba lakes south of 54° 10′N on 11, 12, and 19 June 1979. Islands known to have harbored colonial nesting waterbirds and all nearby islands were checked at a 200 to 300 meter height. Once an active colony was found, passes were made at an altitude of 150 meters to observe birds and nests. When time and water conditions permitted, we landed and made ground counts. During the first day most colonies were ground-truthed, but that was done less frequently thereafter. Single species colony locations and numbers of nests for each appear in Appendix 1A. Colony locations and numbers of nests for colonies with more than one species are in Appendix 1B.

Results

Eared Grebe (*Podiceps nigricollis*)

The Canadian range includes the southern parts of the prairie pothole region from Manitoba's Red River Valley to interior British Columbia (Godfrey 1966). Colonies in Minnesota are confined to the western part (Green and Janssen 1975) whereas North Dakota claims colonies in nearly all sections of the state (Stewart 1975). Thompson (1891) considered it a common breeder throughout the shallow inland lakes and marshes of southern Manitoba, including the Red River marshes (Netley).

Twelve colonies totalling 1 340 nests were recorded. Colonies ranged from 20 to 500 nests, confined to southern marshes west of Lake Winnipeg.

We consider this species to be in decline. Drainage of marshes and shallow lakes has and continues to threaten this grebe which is intolerant of water-level changes (McAllister 1958). The use of herbicides and pesticides and penetration into remote marshes by humans also contribute to its decline.

Western Grebe (*Aechmophorus occidentalis*)

The Canadian distribution includes the prairies of Manitoba, Saskatchewan, and Alberta, with two small pockets in southern British Columbia (Godfrey 1966). Minnesota colonies are restricted, and the species is threatened there (Henderson and Hirsch 1980). North Dakota contains colonies scattered throughout its pothole region (Stewart 1975). Thompson (1891) wrote of large populations on Lakes Shoal, Manitoba, and Winnipegosis as well as on the Waterhen marshes (Shoal Lake was partially drained around 1910, leading to the three separate "Shoal Lakes" of today).

Eleven colonies totalling 5 135 nests were recorded, usually in association with the marshes of large lakes or rivers in the southern and central portion of the study area. Numbers of nests per colony ranged from 5 to 2 400.

We consider this species to be in decline. Owing to their vocalizations and showy open-water displays, breeding Western Grebes attract the attention of humans (Nuechterlein 1975). The birds, however, are intolerant of close human disturbance, changes in marsh vegetation, and water-level fluctuations during the breeding season.

American White Pelican (*Pelecanus erythrorhynchos*)

The distribution of the pelican in Canada indicated that it is primarily a prairie species with isolated colonies in British Columbia and Ontario (Godfrey 1966). Markham (1978a) estimated 15 000 pairs for Canada. Recent studies indicate that Saskatchewan (Roney 1978) and Manitoba contain more than that number of breeding pairs. The United States population of 34 000 birds remained stable at least between 1965 and 1977 (Torres et al. 1977). Ontario recognizes three islands in Lake of the Woods (V. Macin, OMNR, personal communication). Minnesota harbours fewer than 5 colonies (Moyle 1980), and North Dakota contains a single colony (Stewart 1975).

Thompson (1891) listed the pelican as common about the large lakes of southern Manitoba. Rogers (unpublished report) did not find colonies on Lake Winnipeg during his field surveys of the south basin in 1935. Our survey revealed several large colonies within the area surveyed by Rogers. Vermeer (1970a), using visual estimates, found 15 Manitoba nesting islands totalling 6 800 nests on 8 lakes in 1969. Boeker (1972), using air photos, counted 7 388 nests on islands in 5 lakes where Vermeer (1970a) had found 5 760 nests 2 years previously. Pelicans have expanded their range eastward onto Lake Winnipeg in recent years and are considered near a population peak.

Thirty-six islands containing 14 021 nests were recorded. Nest numbers ranged from one to 2 004 per breeding island. Typically, colonies were found on clusters of islands in large lakes, with a major colony island and several small satellites. West of Lake Winnipeg available nesting sites were limited owing to

water retention for potential hydro-electric requirements.

The fact that most colonies consist of a major nesting island with several small colonies on nearby islands suggests recent population increases. Although Manitoba's population is high, the pelican is extremely vulnerable to human disturbance during the breeding season.

Double-crested Cormorant (*Phalacrocorax auritus*)

Cormorant populations occur in all 10 Canadian provinces (Markham 1978b). Four sub-populations are recognized: East Coast, Great Lakes, Prairie and West Coast. The East Coast and Prairie populations comprise 40 000 of the 42 000 breeding estimate for Canada (Markham 1978b). Saskatchewan (Roney 1978) and Manitoba studies indicate that each province harbours more than that Canadian estimate. Saskatchewan's breeding population is confined to 12 colonies in contrast to Manitoba's 60. Ontario colonies occur on a number of islands in Lake of the Woods. The species is endangered in Wisconsin (Les 1979), represented by 2 000 pairs in Minnesota (Henderson and Hirsch 1980), and occurs in 10 North Dakota colonies (Stewart 1975).

The cormorant has been accused of causing declines in Manitoba's commercial fishery. This contention has not been disproven to the satisfaction of fishermen. In the late 1940s to mid-1950s the provincial government assisted in cormorant colony destruction on Lake Winnipegosis (McLeod 1943; 1954; McLeod and Bondar 1953). Numbers of adults on Lake Winnipegosis were considered reduced from 39 448 to 18 624 between 1945 and 1951. Commercial fishermen and recently Manitoba's trout farmers continue to exert pressure for provincial sanction and assistance in eliminating the "Crowduck menace".

Manitoba's cormorant abundance was described by Bent (1922): "Nowhere have I seen greater densities of Double-crested Cormorants than on Manitoba's Lake Winnipegosis." Mendall (1936) recorded a total of 9 320 nests from at least 27 islands on 7 Manitoba lakes. Vermeer (1969) stated that Lake Winnipegosis had as many cormorants breeding on its islands as in all Saskatchewan and Alberta colonies combined, but he recorded only 4 772 nests from 37 islands on 13 Manitoba lakes. Present cormorant numbers in Manitoba are considered near their peak. Part of this build-up could relate to a decrease in the number of commercial fishermen and the absence of human disturbance during the closure of Lake Winnipeg to commercial fishing in the early 1970s (Beyette 1979).

Sixty colonies were found to harbour 22 642 active nests. Numbers ranged from 11 to 2 481 nests per island and were concentrated on the major lakes. Colonies were usually on barren islands although a portion of the colony often nested above ground when trees were available.

The species is vulnerable to disturbance and faces increased competition with humans on nesting islands.

Great Blue Heron (*Ardea herodias*)

The Canadian breeding distribution includes all provinces except Newfoundland (Godfrey 1966). Great Blue Herons were considered by some authors to be in decline throughout much of their range (DesGranges and Laporte 1979) owing to such factors as habitat destruction, human disturbance, and increases of predators such as the Raccoon (*Procyon lotor*). Colonies are restricted and scattered throughout the Canadian Great Lakes and St. Lawrence Seaway area (Blokpoel and McKeating 1978). Minnesota boasts 172 colonies (Henderson and Hirsch 1980), and North Dakota has roughly 50 active heronries (Stewart 1975). Thompson (1891) listed this species as an uncommon erratic summer resident in Manitoba. Manitoba colonies have recently been considered to be more numerous and larger than those in Alberta and Saskatchewan combined (Vermeer and Hatch 1972).

Fifty-two colonies totalling 2 392 nests were recorded. Colonies were found scattered throughout the study area. Numbers of nests ranged from 2 to 350 per colony with larger concentrations generally on islands in large lakes.

Data indicate a population shift or reduction in western Manitoba where Vermeer and Hatch (1972) recorded a dozen colonies in the Duck Mountain Provincial Park area compared to the one active colony there in 1979. Colonies in southern Lake Winnipegosis east of Duck Mountain and the Turtle Mountain colony to the south increased between 1971 and 1979.

The Great Blue Heron in Manitoba is vulnerable to land clearing, logging, marsh draining, human disturbance, and predators.

Black-crowned Night-Heron (*Nycticorax nycticorax*)

The distribution in Canada includes Alberta, Saskatchewan, Manitoba, the St. Lawrence Seaway, New Brunswick and Nova Scotia. They are considered in decline throughout their St. Lawrence range (DesGranges and Laporte 1979). Minnesota populations are confined largely to the southern half of the state (Henderson and Hirsch 1980). Colonies exist throughout the pothole regions of North Dakota (Stewart 1975). Few historic data exist for Manitoba. Thompson (1891) described the species as "somewhat to tolerably common" in southern Manitoba. More colonies surely exist in the Souris and Pembina River basins where none were found despite immature birds being observed there. The species nests both in trees

and in marsh vegetation where nests are difficult to find.

Six colonies totalling 294 nests were found. Colonies which ranged from one to 250 nests were largely confined to the southern and western portion of the study area.

Marsh drainage, pesticides, predators and human disturbance are considered important limiting factors for this species. More data on colony locations, colony consistency information and monitoring of colonies are necessary to determine the status and trends of this species.

Franklin's Gull (*Larus pipixcan*)

The Canadian distribution is primarily restricted to the prairie regions of Manitoba, Saskatchewan, and Alberta, northward almost to the Northwest Territories (Godfrey 1966). Minnesota colonies are listed as a handful confined to the western part of the state (Green and Janssen 1975). North Dakota lists over a dozen colonies in its pothole region (Stewart 1975). North Dakota colonies are generally closely associated with Black-crowned Night-Herons, a relationship not recognized in Manitoba. Thompson (1891) described the Franklin's Gull as common to abundant throughout southern Manitoba. The species has adapted to foraging in cultivated fields, nuisance grounds and other human-manipulated areas. Pesticide use is blamed for considerable reductions of this species on the prairies in the 1930s and 1940s.

Eight colonies totalling 5 550 nests were found. The breeding population is largely confined to larger marshes in southern and western Manitoba where colony sizes range from 75 to 2 000 nests. Several colonies in southwestern Manitoba may have gone undetected as some nesting areas are seldom approached by humans, and nesting locations shift annually according to water levels.

Because of their feeding in tilled fields and at nuisance grounds, Franklin's Gulls are especially vulnerable to pesticides and chemical waste spills.

Ring-billed Gull (*Larus delawarensis*)

The Canadian breeding distribution includes concentrations on the prairies, the Great Lakes and along the east coast. Isolated populations are recognized on Hudson Bay, James Bay, and the Labrador coast (Godfrey 1966). Minnesota has four colonies (Henderson and Hirsch 1980), and several colonies are listed for North Dakota (Stewart 1975). Thompson (1891) considered the species common throughout southern Manitoba. The ability to adapt to humans and recover from persecution has allowed this species to increase over 1000-fold in this century on the Great Lakes and eastward (Ludwig 1974). Populations in Manitoba are considered high and on the rise at present.

Twenty-five colonies were found with nearly 30 000 nests. The population is restricted to islands in larger lakes where as many as 12 000 and as few as 8 nests were counted. The average number of nests per colony was 1 200, the highest for any species considered here. Other Manitoba colonies are known to exist north of the area covered by this study.

Although the Ring-billed Gull is susceptible to human disturbance, toxic wastes and pesticides, it is able to colonize new habitats and adapt to dams, agricultural practices and human refuse disposal. Areas colonized by these gulls are often soon used by other colonial nesters for breeding.

Herring Gull (*Larus argentatus*)

The Herring Gull has a circumpolar distribution, breeding throughout much of Canada with the exception of the prairies, the British Columbia coast, and some islands in the far north (Godfrey 1966). Northern Ontario has Herring Gulls nesting on many lake islands but the species does not nest in the U.S.A. west of the Great Lakes. Thompson (1891) listed the species as common about the major lakes of Manitoba. Their provincial numbers appear stationary or on the increase, with numerous colonies north of the study area.

Fifty colonies with 1 791 nests were found. Colonies occurred in all but southwestern Manitoba, especially on or near islands inhabited by other colonial birds. Densities per island were low, but nests were found on nearly all remote islands with low vegetation or debris present. Other islands containing one or a few nests were undoubtedly overlooked.

Herring Gulls exhibit several natural advantages for survival. They adapt to human disturbance, changing food sources, and variable water conditions. They prefer low-density nesting, often in association with other colonial nesters which nest slightly later. These other species often provide food and predator protection. Low-density nesting makes Herring Gull colony identification and number estimates difficult, especially from the air.

Caspian Tern (*Sterna caspia*)

The Caspian Tern breeds in widely scattered colonies in North America, Europe, Asia, Africa, Australia, and New Zealand (Godfrey 1966). In Canada it is considered rare, with a discontinuous distribution concentrated on the prairies. Two nests in 1969 represent the only records for Minnesota (Green and Janssen 1975). Thompson (1891) did not list the species for Manitoba. The first provincial nesting record was from Lake Winnipeg's Pelican Island in 1918 (O'Donoghue and Nelson 1919). Vermeer (1970b) found two major colonies totalling 710 nests on Lake Winnipegosis and three colonies totalling 1 535 nests

on Lake Winnipeg. He also found small colonies on Lake Manitoba, Moose Lake, Lake Winnipeg and Lake Winnipegosis. Fifty-nine per cent of the Canadian breeding population is in Manitoba (Martin 1978).

Eight colonies with 1 393 nests were recorded. Colonies ranging in size from 10 to 400 nests occurred primarily on sandy islands in the larger lakes. The province's largest colony (Vermeer 1970b), formerly located on a sand spit just south of Lake Winnipeg's Long Point, had recently been abandoned, due in part to a road constructed close to it. We recorded large concentrations of apparently non-breeding terns along the lakeshore south of Long Point. No active colonies were located on Lake Winnipeg, although birds from the former Long Point colony were expected to soon colonize a suitable site.

Caspian Terns appear able to adapt to changing water conditions, colonizing alternate breeding sites. There is, however, a limit to the number of suitable alternative sites available. Their diet of larger fish makes them vulnerable to concentrations of chemical pollutants (Vermeer 1973). Chemical pollutants and human disturbance are considered the major threats to the species in Canada (Martin 1978).

Common Tern (*Sterna hirundo*)

The Canadian breeding distribution extends from western Alberta to the east coast and northward to a colony on the Mackenzie Delta (Godfrey 1966). Northern Ontario records six Lake of the Woods colonies, only one of which has been recently successful (Macin, OMNR, personal communication). Minnesota Common Terns are restricted to northern areas (Green and Janssen 1975). For the Lake Ontario and St. Lawrence River regions Blokpoel (1977) stated: "Although the data are incomplete they indicate a serious decline in numbers of nesting Common Terns in recent years." Common Terns are considered in decline throughout much of their range (Haymes and Blokpoel 1978). Accounts by Thompson (1891) and Rogers (unpublished report) indicated that they were formerly much more common in Manitoba than at present.

Twenty-four colonies totalling 3 684 nests were recorded. Common Terns were found nesting on islands in all parts of the study area although less commonly in the southwest corner of the province. The colonies ranged from 20 to 1 000 nests. Colonies also exist north of the study area. Estimates of nests are considered minimal, as at the time of the survey nesting was just starting in most colonies.

Although considered decreasing in the province, the species is still well represented. Monitoring and status data are needed to determine if special management measures are necessary. Water-level manipulations and human disturbance are considered the major threats to Manitoba's Common Terns.

Forster's Tern (*Sterna forsteri*)

The Canadian breeding distribution is restricted to south-central and western Manitoba, south-central Saskatchewan and southeastern Alberta (Godfrey 1966). A new small colony exists in southeastern British Columbia (Goossen et al. 1982). Fourteen breeding sites are recognized in Minnesota (Henderson and Hirsch 1980). In North Dakota the species is considered uncommon and local throughout the pothole region (Stewart 1975). Thompson (1891) described it as breeding along a number of southern Manitoba lake and river shorelines. Studies by Hatch (1972) indicated that southern and southwest shores of Lake Winnipeg harbour Manitoba's main breeding population. McNicholl (1971) described the breeding biology and ecology of the Forster's Tern at Delta Marsh (Lake Manitoba). Gerrard and Whitfield (1971) listed 13 colonies for Saskatchewan, 4 for Alberta and 16 for Manitoba. Several of those were old records with no recent data.

Fourteen colonies totalling 1 092 nests were found. Most colonies were in the southern portion of the study area, usually associated with large marshes. Typically, several colonies were clustered in a single large marsh with the nest numbers ranging from 2 to 325 per colony.

The future of Manitoba's Forster's Terns is uncertain. The manipulation of water-levels for hydroelectric power, the draining and dyking of marshes, and increased human activity near nesting colonies are and will continue to be threats to their survival.

Management Concepts

Despite detrimental effects due to disturbance, shooting, pesticide use, marsh drainage and various developments, man's influence on Manitoba's colonial nesting waterbirds has been beneficial for some species in some cases. Dams on a number of rivers have provided open water for early migrants and excellent fishing grounds for several species. Agricultural developments have provided food sources for others. On the other hand, increases in Ring-billed Gulls, Herring Gulls, and Franklin's Gulls (assisted by human development) have likely had an adverse impact upon Common Terns, Caspian Terns and Forster's Terns as competition for nesting habitat may be critical. Increases in cormorant and pelican populations are causing concern to commercial fishermen, who are likely to attempt to destroy such birds. As colonies often contain more than one species, uncommon birds such as Caspian Terns or California Gulls (*Larus californicus*) may be destroyed along with the target species. Since 1971, Lake Manitoba

has been regulated so that its water remains fairly stable at high levels. That stability has stagnated marshes, reducing their value for nesting Forster's Terns, Franklin's Gulls, Black-crowned Night-Herons, Western Grebes and Eared Grebes. It has also allowed woody vegetation to encroach upon the shorelines of islands, limiting their value as nesting habitat for cormorants, pelicans, Common Terns, Caspian Terns and Ring-billed Gulls. Cedar Lake once contained colonies of Great Blue Herons, cormorants, Herring Gulls, Ring-billed Gulls and Common Terns. Since 1964 the lake has been managed for winter hydro-electric power production; draw-downs of 16 m and rapid filling each spring have prevented successful colonial waterbird reproduction there in recent years. Lake Winnipeg also is now controlled for power production, but only slight changes in water levels are expected. Even differences of a few centimenters will greatly affect water depths in marshes behind the beach ridge, especially considering wind tides and sieches. According to Evans (1972), fluctuations in water levels are a major long-term advantage to colonial waterbird species, in that periodic high water-levels would assure that trees and other large vegetation would not gain a foothold and thereby destroy the suitability of low-lying islands as potential breeding sites. Lakes Winnipeg and Manitoba now experience only limited fluctuations in water levels.

According to McLeod and Bondar (1953), Double-crested Cormorant chicks with little down died after brief exposure to bright sunlight when their parents were prevented from shading them. Young pelicans were even quicker to die. Hosford (1965) speculated that pelican nests under trees were more vulnerable to disturbance than were nests in open areas as adult birds take longer to return, allowing gulls to steal their eggs. My observations on Kawinaw Lake and those of Val Macin at Lake of the Woods (OMNR, personal communication) suggested that shade afforded an advantage to the portions of colonies located under trees. The type of shade, temperature, nearby predators, time and type of disturbance may be critical.

Ideally, Manitoba's colonial nesting waterbirds should be protected, with colony sites "off limits" to developers and with carefully-limited numbers of visitors during the breeding season. Such regulations should include a provision to enforce protection within a 1 km radius around colonies and a 600 m minimum altitude for aircraft. Dog owners should be made responsible for disturbances caused by their pets. Provincial statutes could protect all colonies, and areas deemed critical could receive better coverage under Ecological Reserve status, as is being implemented in British Columbia.

To acquire adequate management information, monitoring of all known colonies should be done every two to three years. In view of the effects of lake level stabilization and man's influence, favoring some species which are out-competing others, habitat manipulation may be necessary (especially on Lake Manitoba) to maintain suitable habitat for all species involved.

The public should be informed of the damage they cause in disturbing breeding bird colonies. Penalties should be severe enough and education informative enough to limit public trespassing. Proposed developments near colonial waterbird breeding areas should be required to consider the colony size, species impacted, probable effects and area significance before being allowed to proceed. Relocation of developments or mitigation of damage should be required in certain situations.

Acknowledgments

We thank staff from Ducks Unlimited Canada, Provincial Natural Resources, Canadian Wildlife Service and Riding Mountain National Park and provincial bird enthusiasts for their data contribution and support; and also Mike Watson, Delta Waterfowl Research Station, for assisting as an aerial observer for the northern lakes and Robert W. Nero for editorial assistance.

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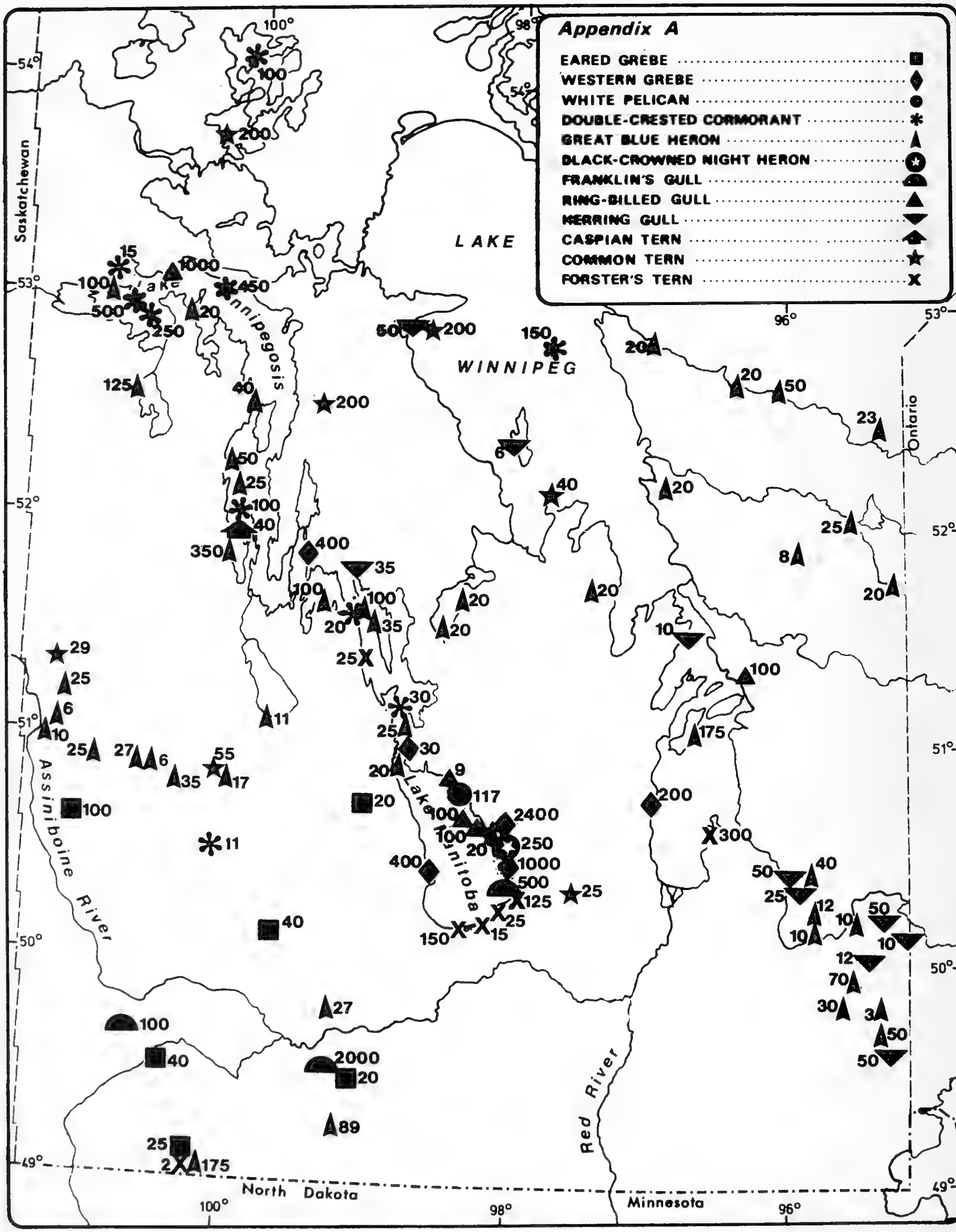
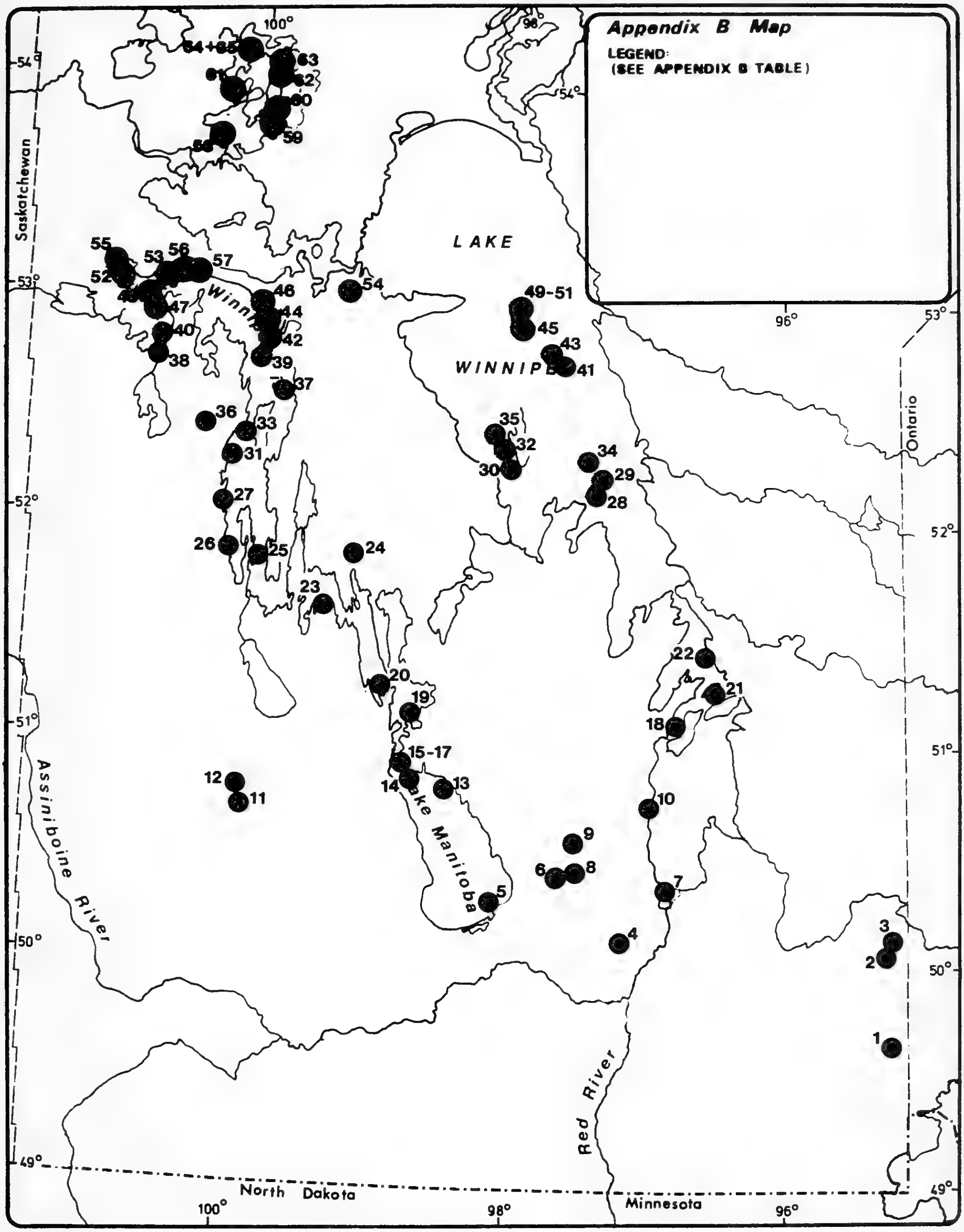
Received 19 November 1982
Accepted 13 June 1984



Appendix A
EARED GREBE
WESTERN GREBE
WHITE PELICAN
DOUBLE-CRESTED CORMORANT
GREAT BLUE HERON
BLACK-CROWNED NIGHT HERON
FRANKLIN'S GULL
RING-BILLED GULL
HERRING GULL
CASPIAN TERN
COMMON TERN
FORSTER'S TERN
LAKE WINNIPEG
Lake Winnipegosis
Lake Manitoba
Saskatchewan
Ontario
Assiniboine River
Red River
North Dakota
Minnesota
100°
98°
96°
54°
53°
52°
51°
50°
49°


Appendix B Map
LEGEND:
(SEE APPENDIX B TABLE)
LAKE
WINNIPE
Lake Manitoba
Saskatchewan
Ontario
Assiniboine River
Red River
North Dakota
Minnesota
100°
98°
96°
54°
53°
52°
51°
50°
49°
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15-17
18
19
20
21
22
23
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37
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41
42
43
44
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49-51
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59
60
62
63
64+65

Appendix B Table

Nest estimates for multiple species colonies
(some consisted of two or more associated islands).

Eared Grebe (EG)	Double-crested Cormorant (DcC)	Franklin's Gull (FG)	Caspian Tern (CpT)		
Western Grebe (WG)	Great Blue Heron (GBH)	Ring-billed Gull (RBG)	Common Tern (CT)		
White Pelican (WP)	Black-crowned Night-Heron (BcNH)	Herring Gull (HG)	Forster's Tern (FT)		

	Nest number by species											
Location Number	EG	WG	WP	DcC	GBH	BcNH	FG	RBG	HG	CpT	CT	FT
1									10		25	
2										10	25	
3									14	10	50	
4	25	5				10	2000		6			15
5								900				500
6			19	152				8			20	
7	400	50					400					375
8			1247	104					232		50	
9	500	400				6						
10							275		10			
11	50						200					
12											35	35
13			230	250				25	100			
14			1050	2481		12		2800	12			
15			50	55					10			
16			35	60								
17								300		450		
18								50			25	25
19			1000	50	50			3000				
20				200	2	1			1			
21				187					37			
22			1500	500				1000	300			
23				466					33			
24	20						75					
25	100	150										
26				170				1700	8			
27				150					10			
28				200				200				
29			75	800					10			
30			20	25								
31				60	30							
32			1250	2368	5	15					348	
33				200				2000		100	1000	
34				75				900				150
35			25	150					10			
36			1000	1500								
37				50					5	250	200	
38		100									55	
39				800				300		150		
40				526					5			
41				100					10			
42				450				300				
43				150				300				
44			2004	163	26			12000	175		50	
45			60	125					50			
46				300					50			
47				35							200	
48				200					20			
49				25					15			

Appendix B Table (concluded)

Nest estimates for multiple species colonies.
(some consisted of two or more associated islands)

Eared Grebe	(EG)	Double-crested Cormorant	(DcC)	Franklin's Gull	(FG)	Caspian Tern	(CpT)
Western Grebe	(WG)	Great Blue Heron	(GBH)	Ring-billed Gull	(RBG)	Common Tern	(CT)
White Pelican	(WP)	Black-crowned Night-Heron	(BcNH)	Herring Gull	(HG)	Forster's Tern	(FT)

	Nest number by species											
Location Number	EG	WG	WP	DcC	GBH	BcNH	FG	RBG	HG	CpT	CT	FT
50			1	50							50	
51			100	75								
52				450	100							
53			800	900								
54				25					20			
55				150				500				
56				2300	60			2000				
57			918	2009				59		383	152	
58			1500	800								
59				200					30			
60				35				50	10			
61			10	50								
62			100	175					50			
63			50	50					50			
64			800	250					200			
65			60	100								

New and Interesting Vascular Plant Records from Northern Ontario

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Riley, J. L., and S. Walshe. 1985. New and Interesting Vascular Plant Records from Northern Ontario. Canadian Field-Naturalist 99(1): 30–33.

Aster radula, Astragalus tenellus, Kalmia microphylla, Picea glauca var. *porsildii,* and *Sedum aizoon* are new to the flora of Ontario. Documentation is also presented for four species previously mapped or reported for Ontario without specimen citations: *Calamagrostis lapponica, Juncus interior, Salix arbusculoides* and *Utricularia ochroleuca.*

Key Words: floristics, vascular plants, new records, phytogeography, Canada, Ontario, northern Ontario.

During field studies in northern Ontario over the past six years several species have been added to the provincial flora (Riley 1979). Here we offer brief notes on a further five additions to the provincial flora, four of them native taxa which are notable rarities and range extensions. A further four species which have been previously mapped or reported without specimen citation are documented as to their occurrence in Ontario. Figure 1 maps their presently understood occurrences in Ontario.

Aster radula Aiton

Cochrane District: 50°35′N, 80°05′W; open graminoid fen, pH 5.3, water depth 0 to –35 cm, peat depth 2.5 m over clay till, dom. *Scirpus cespitosus — Sphagnum fuscum — Campylium stellatum — Potentilla fruticosa-Carex exilis;* (just west of Kesagami River, *ca.* 20 km downstream from Kesagami Lake). *Riley 11194,* 24 July 1979 (TRT).

Cochrane District: 50°44′N, 79°54′; open graminoid fen, pH 6.4, water depth 0 to – 20 cm, peat depth 2 m over sand, dom. *Drepanocladus revolvens-Scirpus cespitosus-Carex lasiocarpa-Sphagnum fuscum-Scorpidium scorpioides-Potentilla fruticosa*; (just east of Lowakamistik River, *ca.* 15 km upstream from Atik River). *Riley 11213,* 24 July 1979 (TRT).

These are the first Ontario records of this small aster, extending its known range westward from Quebec (north to Great Whale River, south to Abitibi), Labrador, the Maritime Provinces, the eastern seaboard of the United States, and south to West Virginia in the Appalachians (Scoggan 1979; Boivin 1966). In habitat and appearance, *Aster radula* resembles *A. nemoralis,* from which it can be readily distinguished by the distinct toothing of the leaves, the firm, obtuse involucral bracts, and the glabrous achenes. These two species are not sympatric in their Ontario ranges as *A. nemoralis* only extends as far north as Lake Temagami and Lake Superior Provincial Park.

Astragalus tenellus Pursh

Cochrane District: 50°48′N, 84°28′W; dry, southfacing, juniper-aspen river slope, Kenogami River near Wakashi River. *Riley 10467,* 8 July 1979 (TRT).

This is the first record for Ontario; determination confirmed by R. Barneby (1980, personal communication, New York botanical Garden) as a 'substantial range extension'. *Astragalus tenellus,* the pulse milk-vetch, is a diffuse, small-flowered species of dry sites, prairies and woodlands of the west. It is known from southwestern Manitoba as far north as the Grand Rapids area, with an introduced population in a gravel pit near Gillam (*Schofield 1261,* Gillam, 25 July 1950; DAO, WIN: Scoggan 1979). This native Ontario population parallels the disjunct distribution of *Astragalus agrestis* from Manitoba to Albany (*Lepage 30105,* Albany, 24 July 1954, CAN), as possible relict populations of formerly more widespread species of *Astragalus.*

Calamagrostis lapponica (Wahl.) Hartm.

Kenora District: diabase cliffs and ridges west of narrows between Hawley and Sutton Lakes. *Porsild 21069, Baldwin, Sjors,* 4 July 1957 (CAN) (*conf.* C. W. Greene).

Kenora District: Clay bank along winter road between Ponask and Sachigo Lakes, infrequent. *Moir 4595,* 9-12 August 1957 (CAN) (*det.* A. E. Porsild, *conf.* C. W. Greene).

Kenora District: 54°28′N, 84°50′W; in patches near the ridge crest in shallow but peaty sites, over Precambrian rock, Sutton Narrows ridge. *Sims 2770Bi,* 23 July 1979 (TRT).

Kenora District: 54°21′40″N, 84°34′10″W; open Precambrian rock outcrop summit, dom. by *Potentilla tridentata, Vaccinium uliginosum,* crustose lichens; outcrop ca. 1 km east of central part of Aquatuk Lake, Sutton Ridges. *Riley 11934,* 15 August 1980 (TRT).

This species was not recorded for Ontario by Dore and McNeil (1980), Boivin (1981) or Scoggan (1978),

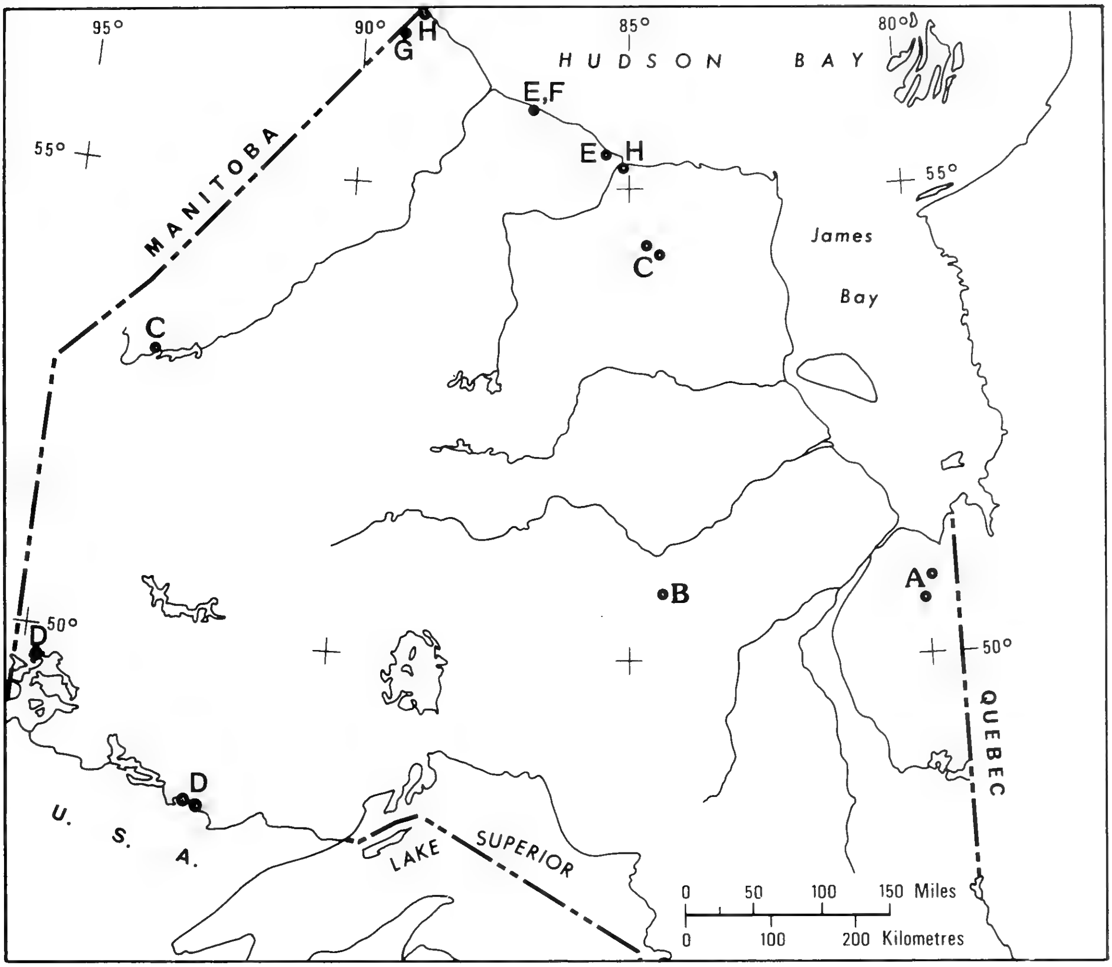

FIGURE 1. Cited Ontario locations of *Aster radula* (A), *Astragalus tenellus* (B), *Calamagrostis lapponica* (C), *Juncus interior* (D), *Kalmia microphylla* (E), *Picea glauca* var. *porsildii* (F), *Salix arbusculoides* (G), *Utricularia ochroleuca* (H).

but was mapped from northeasternmost Ontario by Porsild and Cody (1980). Resembling a slight *C. canadensis* with a narrow, lax panicle, the range of this arctic-subarctic species is Labrador, northern Quebec, northern Ontario and northern Manitoba, extending northwest to Alaska and south in the western cordillera.

Juncus interior Wieg.

Kenora District: Clearwater Bay, Lake of the Woods. *W. L. Gordon,* 3 September 1946 (DAO, originally *sub J. tenuis,* annotated by V. R. Brownell and P. M. Catling in 1982).

Rainy River District: in granitic crevices, northeast shore of Gardner Bay of Crooked Lake. *Walshe 76*–220, 9 July 1976 (CAN, originally *sub J. dudleyi,* annotated by V. R. Brownell and P. M. Catling in 1982).

Rainy River District: in granitic crevices near waterline, Rebecca Falls, Quetico Provincial Park. *Walshe* 76–263, 15 July 1976 (CAN, Quetico Park Herbarium).

This prairie species occurs from Illinois and Missouri west to Texas and Idaho, rarely east to Ohio. Distinguishable from *J. dudleyi* by its non-coriaceous leaf auricles and from *J. tenuis* by its short rounded membranous auricles, the cited specimens are the basis for the new record for Ontario and Canada reported by Walshe (1980; "Gardner Bay of Crooked Lake and at Rebecca Falls on Iron Lake"). The occurrence of this species at Clearwater Bay was discovered through a herbarium search by V. R. Brownell and

P. M. Catling (DAO).

Kalmia microphylla (Hooker) A. Heller (*K. polifolia* Wangenheim var. *microphylla* (Hooker) Rehder)
Kenora District: 55°52′N, 86°48′W; mossy interridge tundra, open *Salix* thickets, mouth of Shagamu River, 2 mi (3.2 km) inland, 1 mi (1.6 km) west of river. *Riley 7250,* 1 August 1977 (TRT).
Kenora District: 55°25′N, 85°26′W; lichen-White Spruce woodland dominating a raised beach about 2 km from shore, Hudson Bay coast northwest of Winisk. *Riley 6169,* 27 August 1976 (TRT).

These are the first Ontario records (Scoggan 1979; Boivin 1968; Soper and Heimburger 1982), confirmed by D. J. White (National Museum, Rare and Endangered Plants Program) in 1982. Southall and Hardin (1974) stress leaf shape and general habit in separating *Kalmia microphylla* from *K. polifolia,* the widespread eastern Canadian bog-laurel: the former with leaves usually less than 2X longer than wide, and 10–20 cm tall; the latter with leaves usually more than 2 × longer than wide, over 30 cm tall. These authors did not report any material from Canada east of the Alberta Rockies. Other authors, recognizing the taxon as a species, or as a subspecies or variety of *K. polifolia,* also distinguish *K. microphylla* as generally smaller, having less revolute leaf margins, and/or leaves with glabrous (*vs.* pubescent glandular) midribs (Boivin 1967; Hultén 1968; Porsild and Cody 1980). Of these authors, only Scoggan refers to the taxon occurring east of Alberta, specifically Baralzon Lake in the District of Keewatin. White and Johnson (1980) report *K. microphylla* from the Churchill area, based on a specimen at CAN (*Barlow 49,* Farnworth Lake, 17 July 1950). (Cytological evidence for maintaining this taxon at the species level is summarized by Jaynes (1969)).

Picea glauca (Moench) Voss var. *porsildii* Raup
Kenora District: 55°52′N, 86°48′W; dry lichen-dominated beach ridge, mouth of Shagamu River, 2 mi (3.2 km) inland, 1 mi (1.6 km) west of river. *Riley 7191,* 31 July 1977 (TRT).

Picea glauca var. *porsildii* (Raup 1947; Porsild and Cody 1980) is a distinctive tree which has smooth, light-grey bark with visible, *Abies*-like resin blisters. It is reported from northern British Columbia, Yukon, Alaska and the District of Mackenzie (Scoggan 1978; Hultén 1968), but not recognized as a distinctive variety by Boivin (1966). Var. *porsildii* was reported as occurring at Houston Point on Akimiski Island, James Bay (Riley 1981), but no other eastern records are known to the authors. This distinctive spruce, often occurring as partial *krummholz* on raised beach ridges, forms the most seaward rank of trees in the vicinity of the mouth of the Shagamu River, east of Fort Severn on Hudson Bay.

Salix arbusculoides Andersson
Kenora District: 56° 41′N, 89° 14′W; littoral habitats, calcareous clays and silts, lower Black Duck River. *Riley 8533,* 17 July 1978 (TRT).

The cited specimen is the only record of this western, subarctic-temperate shrub in Ontario, its determination confirmed by G. W. Argus (National Museum). Known from four locations in northern Manitoba, where it is considered a 'rare' species (White and Johnson 1980), it is also disjunct to Lake Mistassini in central Quebec. This record is the basis of the inclusion of this species among the 'Shrubs of Ontario' (Soper and Heimburger 1982).

Sedum aizoon L.
Cochrane District: 50°03′N, 82°10′W; adventive and spreading on granitic outcrops, Smoky Falls. *Riley 10775,* 15 July 1979 (TRT).

This attractive stonecrop was doubtlessly introduced to Smoky Falls as part of horticultural plantings which remain of some interest as examples of northern plantings for this part of Ontario; also persisting there are *Acer negundo, A. ginnala, A. saccharinum, Syringa villosa, S. vulgaris, Salix pentandra, Sorbaria sorbifolia, Cotoneaster* cf. *acutifolia,* and others (TRT). The determination of *Sedum aizoon* was confirmed by R. T. Clausen (1980, personal communication, Cornell University), who wrote 'the record is the first to come to my attention indicating naturalization of this species in North America'. A check of herbaria produced another Ontario specimen (*Garton 18367,* railway service yard in Current River area, Thunder Bay City, evidently an escape, 20 July 1978, TRT, LKHD). This species is not reported from Ontario by Scoggan (1978) or Boivin (1966), but may be more widely adventive than herbaria records indicate and may be naturalized at some locations.

Utricularia ochroleuca R. Hartman
Kenora District: vicinity of the mouth of the Black Duck River; in flooded sedge meadow. *Moir 2260,* 29 July-1 August 1953 (CAN, originally *sub U. intermedia,* annotated by A.E. Porsild).
Kenora District: 55° 14′N, 85° 07′W; open freshwater sedge fen, water up to 2 ft. [sic] deep; Winisk airport, west of main hanger. *Riley 6155,* 26 August 1976 (TRT).

Utricularia ochroleuca is similar vegetatively to *U. intermedia,* but has bladders on leafy branches and has a generally more northern distribution in Canada although occurring within the range of *U. intermedia.*

This circumpolar taxon has been considered of hybrid origin (Boivin 1966; Scoggan 1979), but this remains conjectural. Other recent authors treat it as a viable species (Ceska and Bell 1973; Porsild and Cody 1980; Tutin et al. 1972). Boivin (1966) and Porsild and Cody (1980, mapped) refer to this species occurring in Ontario, on the basis of Moir's 1953 specimen which was originally identified as *U. intermedia.* The record from Winisk extends its known range in Ontario eastward by 300 km.

Acknowledgments

The field studies during which many of these specimens were collected were supported by the Ontario Centre for Remote Sensing, Ontario Ministry of Natural Resources and Canadian Wildlife Service. Determination or confirmation of some of the specimens was assisted by G. W. Argus, V. R. Brownell, R. Barneby, P. M. Catling, R. T. Clausen, A. A. Reznicek, and D. J. White.

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Received 30 November 1982
Accepted 6 February 1984

Floodplain Succession on the West Coast of Vancouver Island

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Clement, Christopher J. E. 1985. Floodplain succession on the west coast of Vancouver Island. Canadian Field-Naturalist 99(1): 34–39.

During 1982, 29 vegetation plots were selected and sampled on the floodplains of the Tahsish and Artlish Rivers. Information collected, for use in a wildlife habitat mapping project, included total plant species, per cent cover, distribution, vigour, soils data and environmental information. The data illustrate successional patterns of the floodplain and variability of plant species composition and cover values in pioneer seral, young seral and mature climax stages. Many initial colonizing plants quickly disappear and are replaced by shade tolerant plants in the young seral stage. These plants, representing more stable ecosystem conditions, increase in cover in the mature climax stage. Characteristic of climax forests are Sitka Spruce (*Picea sitchensis*), Salmonberry (*Rubus spectabilis*), Cooley's Hedge-nettle (*Stachys cooleyae*), Trifoliate-leaved Foamflower (*Tiarella trifoliata*) and Western Sword Fern (*Polystichum munitum*).

Key Words: floodplain, succession, vegetation, pioneer, seral, climax, cover.

During the summer of 1982 vegetation data were collected in two west coast watersheds, in order to map successional stages. Because of resource use conflicts the information was required for assessing present and potential habitat use by Black-Tailed Deer (*Odocoileus hemionus columbianus*) and Roosevelt Elk (*Cervus elaphus roosevelti*). Roosevelt Elk are present in relatively small numbers on Vancouver Island and because their winter habitat requirements, of mature Sitka Spruce (*Picea sitchensis*) forests in floodplains, are in direct conflict with logging concerns their future is in jeopardy. The project was funded by the British Columbia Ministry of Forests and was implemented with the purpose of resolving the land use conflict impartially with objective data. Nomenclature and common names of vascular plants is after Taylor and MacBryde (1977), of mosses after Crum, Steere and Anderson (1973) and of liverworts after Stotler and Crandall-Stotler (1977) with the exception of *Kindbergia* used to replace *Stokesiella* for *K. oregana* (Ochyra 1982).

Study Area

The study area consisted of the lower Tahsish and Artlish watersheds (see Figure 1) located on the north west coast of Vancouver Island at approximately 50° 10′ latitude and 127° 05′ longitude. Both drainages flow into inlets and, as well as providing habitat for Black-tailed Deer and Roosevelt Elk, are important salmon spawning streams.

The area is defined as belonging to the Wetter Maritime Northern Subzone of the Coastal Western Hemlock Biogeoclimatic Zone by Klinka et al. (1980) and is subject to heavy annual precipitation often concentrated into short intensive storms. As a result the rivers and creeks are prone to dramatic flow increase and are capable of transporting large volumes of sediments.

Although upper valleys are typically steep-sided (110%) and narrow, lower portions of the Tahsish and Artlish rivers have a wide flat floodplain. Stable areas of the floodplain develop open forests of Sitka Spruce with dense thickets of Salmonberry (*Rubus spectabilis*).

Methods

Fieldwork was conducted in July, August (Tahsish), September and October (Artlish) and consisted of selecting characteristic sites of each successional stage and compiling a list of trees, shrubs, herbs and bryophytes using a standardized data collection form (Walmsley et al. 1980). Twenty-nine plots were sampled on floodplain sites. For each plant species per cent cover, distribution and vigour were estimated visually. Although plots were not actually measured, the approximate size within areas of homogeneous vegetation units was ten metres square. Information also recorded included soil description, physical site conditions and wildlife features (browse signs, pellets, snag use). Access was limited and most sites were reached either by walking from campsites or by helicopter. Plot locations were marked on 1:20 000 black and white aerial photographs and were later correlated to map units (see Figure 1 for location of plots). Data were sorted into pioneer seral, young seral and mature climax stages. A synthesis table (Mueller-Dombois and Ellenberg 1974) was compiled (see Table 1) to illustrate changes in species composition and cover values throughout the successional stages.

Results

Succession on the Sitka spruce floodplain typically begins with formation of new gravel bars. These vary in texture from sandy to bouldery. Initial plant species to colonize the unvegetated substrate include Douglas-fir (*Pseudotsuga menziesii*), Western Red Cedar

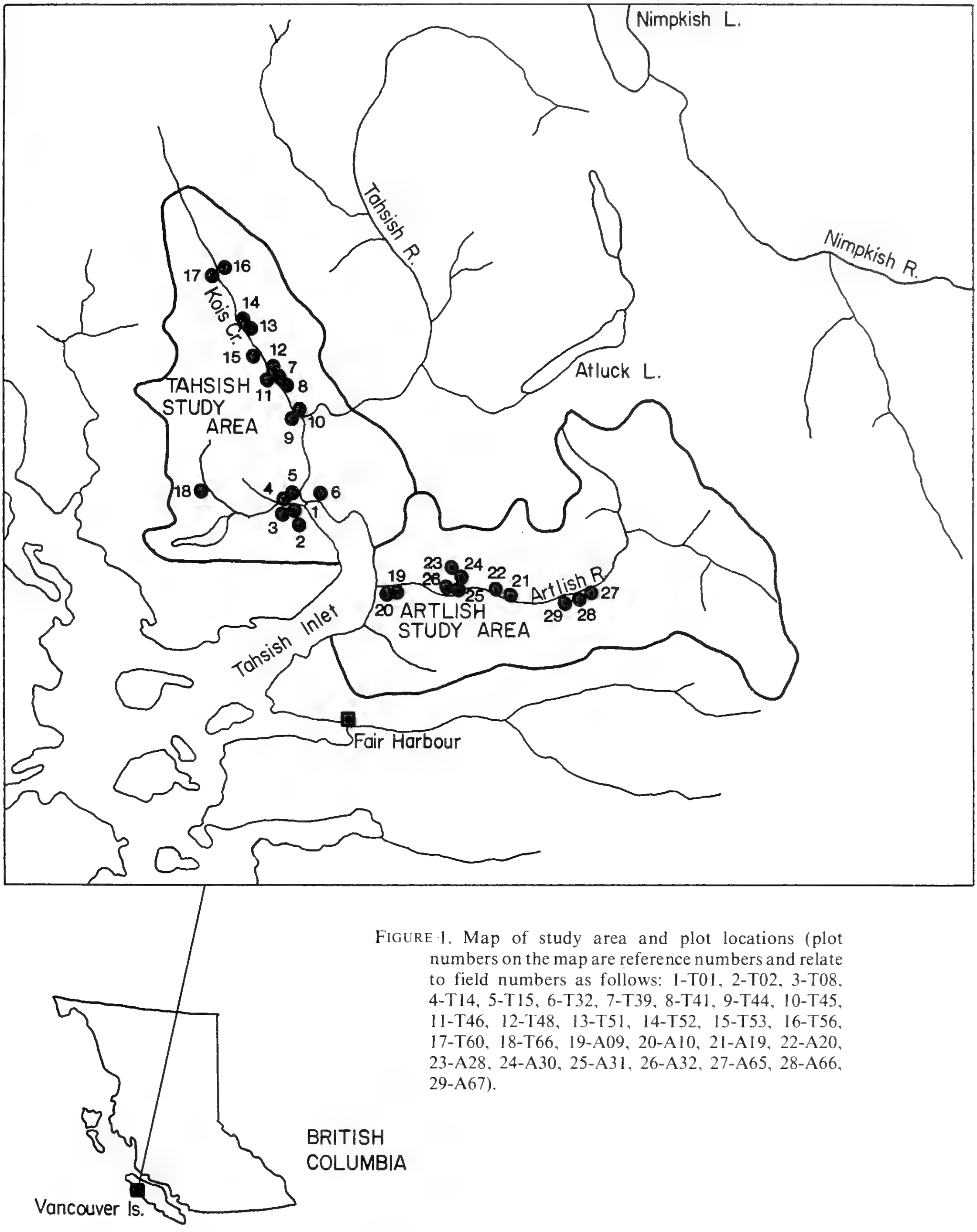

FIGURE 1. Map of study area and plot locations (plot numbers on the map are reference numbers and relate to field numbers as follows: 1-T01, 2-T02, 3-T08, 4-T14, 5-T15, 6-T32, 7-T39, 8-T41, 9-T44, 10-T45, 11-T46, 12-T48, 13-T51, 14-T52, 15-T53, 16-T56, 17-T60, 18-T66, 19-A09, 20-A10, 21-A19, 22-A20, 23-A28, 24-A30, 25-A31, 26-A32, 27-A65, 28-A66, 29-A67).

TABLE 1. Summary of collected data for floodplain successional stages *(concluded).*

Successional Stage	Pioneer Seral						
Plot Numbers[1]	T01	T45	A20	A32	A67	C	MC
Plant Species[2]							
TREE LAYER							
Alnus rubra							
Acer macrophyllum							
Picea sitchensis							
Tsuga heterophylla							
Thuja plicata							
SHRUB LAYER							
Pseudotsuga menziesii		0.5		0.5	0.5	60	0.3
Thuja plicata		0.5	0.5	0.5	0.5	80	0.4
Rubus parviflorus		0.5	0.5	0.5	1	80	0.5
Salix sitchensis	2	0.5	1		5	80	1.7
Tsuga heterophylla				0.5		20	0.1
Ribes bracteosum			0.5			20	0.1
Alnus rubra	4	3	1	20	15	100	8.6
Picea sitchensis	1	1		0.5	1	80	1.7
Rubus spectabilis	1		0.5		0.5	60	0.4
Acer macrophyllum							
Sambucus racemosa							
Vaccinium ovalifolium							
Acer glabrum							
Vaccinium parvifolium							
Vaccinium alaskaense							
Oplopanax horridus							
Abies amabilis							
HERB LAYER							
Arenaria spp.					0.5	20	0.1
Romanzoffia sitchensis			0.5			20	0.1
Sibbaldia procumbens					.5	20	0.1
Taraxacum officinale	1					20	0.2
Campanula rotundifolia		0.5	0.5			40	0.2
Epilobium ciliatum	1			0.5		40	0.3
Montia parvifolia	1	1				40	0.4
Fragaria virginiana				0.5	0.5	40	0.2
Achillea millefolium	0.5	0.5			0.5	60	0.3
Hypochaeris radicata	0.5	2			0.5	60	0.6
Anaphalis margaritacea	0.5	0.5	0.5	0.5	1	100	0.6
Aquilegia formosa		0.5	0.5	0.5	1	80	0.5
Boykinia occidentalis		0.5				20	0.1
Luzula parvifolia				0.5		20	0.1
Trisetum cernuum	0.5					20	0.1
Carex canescens		0.5		0.5		40	0.2
Agrostis sp.	0.5		0.5	0.5		60	0.3
Prunella vulgaris	2		0.5		0.5	60	0.6
Viola sp.				0.5	0.5	40	0.2
Elymus spp.	5	1	0.5	1	5	100	2.5
Mycelis muralis	0.5	1	0.5	1	5	100	2.0
Galium triflorum			0.5	0.5	0.5	60	0.3
Tolmiea menziesii	0.5					20	0.1
Stachys cooleyae		0.5			0.5	40	0.2
Osmorhiza chilensis							
Geum macrophyllum							
Dicentra formosa							
Circaea alpina							
Poa marcida							
Claytonia sibirica							
Trautvetteria caroliniensis							
Melica subulata							
Ranunculus spp.							
Pleuropogon refractus							
Bromus spp.							
Adiantum pedatum							
Veratrum viride							

Successional Stage	Young Seral												
Plot Numbers[1]	T08	T14	T39	T46	T51	T56	T66	A10	A19	A29	A66	C	MC
Plant Species[2]													
TREE LAYER													
Alnus rubra	65	40		65	55	40	35	65	15	20	45	91	40.4
Acer macrophyllum		5								25		18	2.7
Picea sitchensis						5			5			18	0.9
Tsuga heterophylla		10				5						18	1.4
Thuja plicata													
SHRUB LAYER													
Pseudotsuga menziesii													
Thuja plicata													
Rubus parviflorus													
Salix sitchensis	2											9	0.2
Tsuga heterophylla						2	0.5					18	0.2
Ribes bracteosum	5	15	1		2			0.5	2	15		64	3.7
Alnus rubra			5	10	5	10	10	20	15			64	6.8
Picea sitchensis	1	5	30	5	5			2	5	1	40	82	8.5
Rubus spectabilis	40	60	10	20	75	30	70	20	50	90	15	100	39.1
Acer macrophyllum				5				0.5				18	0.5
Sambucus racemosa							0.5					9	0.1
Vaccinium ovalifolium						2			5			18	0.6
Acer glabrum													
Vaccinium parvifolium													
Vaccinium alaskaense													
Oplopanax horridus													
Abies amabilis													
HERB LAYER													
Arenaria spp.													
Romanzoffia sitchensis													
Sibbaldia procumbens													
Taraxacum officinale													
Campanula rotundifolia													
Epilobium ciliatum													
Montia parvifolia													
Fragaria virginiana													
Achillea millefolium													
Hypochaeris radicata													
Anaphalis margaritacea													
Aquilegia formosa									1			9	0.1
Boykinia occidentalis								0.5				9	0.1
Luzula parvifolia	0.5			0.5				2				27	0.3
Trisetum cernuum							0.5					9	0.1
Carex canescens						2						9	0.2
Agrostis sp.					0.5							9	0.1
Prunella vulgaris			2						0.5			18	0.6
Viola sp.	5	1			1	2	10	2	1			64	1.9
Elymus spp.	2		5		10	20			10			45	4.1
Mycelis muralis	1		0.5	1					10	5	2	54	1.8
Galium triflorum	2	2	0.5	2			2	1	2	0.5	3	82	1.4
Tolmiea menziesii	5	10		1	40	20	5		5	70	0.5	82	14.2
Stachys cooleyae	30	10	25	10	5	10	20	30	10		10	91	14.5
Osmorhiza chilensis	2				0.5		0.5	2				36	0.4
Geum macrophyllum						1						9	0.1
Dicentra formosa	1	2	0.5		0.5		1					45	0.4
Circaea alpina	2	40					10		1		5	45	5.3
Poa marcida			0.5	1		0.5	0.5		1			45	0.3
Claytonia sibirica	2	2		2	2		1				2	54	1.0
Trautvetteria caroliniensis		5	0.5	5	20	0.5	3	0.5	2		5	82	3.8
Melica subulata	3	3	30	5	2		5	5	2		2	82	3.8
Ranunculus spp.	1				1		0.5		2		0.5	45	0.4
Pleuropogon refractus				10			0.5	5		2		36	1.6
Bromus spp.	2	3						15				27	1.8
Adiantum pedatum				0.5			0.5	2	0.5	2	2	54	0.7
Veratrum viride							0.5					9	0.1

Successional Stage	Mature Climax														
Plot Numbers[1]	T02	T15	T32	T41	T44	T48	T52	T53	T60	A09	A30	A31	A65	C	MC
Plant Species[2]															
TREE LAYER															
Alnus rubra					5									8	0.4
Acer macrophyllum		5			20									15	2.0
Picea sitchensis	10	20	15	25	30	10	35	55	25	35	30	15	25	100	25.4
Tsuga heterophylla	40	5	5	10	2	50	5	10	30		5		10	85	13.2
Thuja plicata					3			5			10			23	1.4
SHRUB LAYER															
Pseudotsuga menziesii															
Thuja plicata															
Rubus parviflorus															
Salix sitchensis															
Tsuga heterophylla	7			10			2				7			31	2.0
Ribes bracteosum		7	5		2							15	10	38	3.0
Alnus rubra				5	10					5	1		5	38	2.0
Picea sitchensis												5		8	0.4
Rubus spectabilis	50	70	90	10	40	45	20	2	7	15	10	40	60	100	35.3
Acer macrophyllum															
Sambucus racemosa											1			8	0.1
Vaccinium ovalifolium	10								5					15	1.2
Acer glabrum		20	2											15	1.7
Vaccinium parvifolium	2			35		10	10	30	2	7		2		62	7.5
Vaccinium alaskaense	40			25		15	10	2	1					46	7.2
Oplopanax horridus						0.5						2	0.5	23	0.2
Abies amabilis							0.5							8	0.1
HERB LAYER															
Arenaria spp.															
Romanzoffia sitchensis															
Sibbaldia procumbens															
Taraxacum officinale															
Campanula rotundifolia															
Epilobium ciliatum															
Montia parvifolia															
Fragaria virginiana															
Achillea millefolium															
Hypochaeris radicata															
Anaphalis margaritacea															
Aquilegia formosa															
Boykinia occidentalis															
Luzula parvifolia							1	0.5						15	0.1
Trisetum cernuum	0.5	1		5		0.5	5		1		2			54	1.2
Carex canescens							0.5				0.5			15	0.1
Agrostis sp.										2				8	0.2
Prunella vulgaris					1									8	0.1
Viola sp.							0.5	0.5	2	5	1			38	0.7
Elymus spp.					3									8	0.2
Mycelis muralis		2			2			1		1	2		1	46	0.7
Galium triflorum		5	5	1	2				2	2	2	2	2	69	1 8
Tolmiea menziesii		2	10		3						0.5	20	5	46	3.1
Stachys cooleyae		20	1	5	15		5	2		20	10	40	30	77	11.4
Osmorhiza chilensis															
Geum macrophyllum															
Dicentra formosa					0.5									8	0.1
Circaea alpina		10	10		10	0.5	10					5	5	54	3.9
Poa marcida							0.5		0.5	1				23	0.2
Claytonia sibirica			0.5		1							2	3	31	0.5
Trautvetteria caroliniensis	0.5	2	0.5	0.5	1	5	10	3	1	3	1		3	92	2.3
Melica subulata		5					5			10				23	1.5
Ranunculus spp.										0.5			3	15	0.1
Pleuropogon refractus		1			5		2	0.5	0.5	1	1			54	0.8
Bromus spp.										5	2	15	3	31	2.0
Adiantum pedatum		1			0.5						0.5	2	5	38	0.7
Veratrum viride													1	8	0.1

TABLE 1. Summary of collected data for floodplain successional stages *(concluded)*.

Successional Stage	Pioneer Seral						
Plot Numbers[1]	T01	T45	A20	A32	A67	C	MC
Plant Species[2]							
Heracleum sphondylium							
Petasites palmatus							
Festuca spp.							
Tiarella laciniata							
Adenocaulon bicolor							
Blechnum spicant							
Maianthemum dilatatum							
Athyrium filix-femina							
Tiarella trifoliata							
Polystichum munitum							
Cinna latifolia							
Moneses uniflora							
Angelica sp.							
Streptopus roseus							
Gymnocarpium dryopteris							
MOSSES AND LIVERWORTS							
Polytrichum sp.	10	5				80	3
Rhacomitrium heterostichum	70	45	1	40		80	31
Leucolepis menziesii							
Kindbergia oregana							
Mnium spp.							
Marchantia polymorpha							
Hylocomium splendens							
Rhytidiadelphus loreus							

Successional Stage	Young Seral												
Plot Numbers[1]	T08	T14	T39	T46	T51	T56	T66	A10	A19	A28	A66	C	MC
Plant Species[2]													
Heracleum sphondylium								0.5				9	0.1
Petasites palmatus								2				9	0.2
Festuca spp.	1				1		0.5	2	5		1	54	0.5
Tiarella laciniata										0.5		9	0.1
Adenocaulon bicolor	0.5	3		1			1		1		1	54	0.7
Blechnum spicant				0.5			0.5					18	0.2
Maianthemum dilatatum				2		2		15		3		36	2.0
Athyrium filix-femina	1	3		0.5	0.5	0.5	0.5			5		64	1.0
Tiarella trifoliata	1	2		10		2	1		3	5	7	73	2.8
Polystichum munitum		10	5	30	5	50	2	2	10	3	15	91	12.0
Cinna latifolia													
Moneses uniflora													
Angelica sp.													
Streptopus roseus													
Gymnocarpium dryopteris													
MOSSES AND LIVERWORTS													
Polytrichum sp.													
Rhacomitrium heterostichum													
Leucolepis menziesii	15	20					5		20	5	40	54	9.5
Kindbergia oregana	10	10	5	2	10			30	5		30	73	9.3
Mnium spp.	10	10	5	10	30	10	30		10	60		82	15.9
Marchantia polymorpha							5			30		18	3.2
Hylocomium splendens			65	5			2		3		10	45	7.7
Rhytidiadelphus loreus	5		5	15	10	2		5	3	5	10	82	5.4

Successional Stage	Mature Climax														
Plot Numbers[1]	T02	T15	T32	T41	T44	T48	T52	T53	T60	A09	A30	A31	A65	C	MC
Plant Species[2]															
Heracleum sphondylium													2	8	0.1
Petasites palmatus										2				8	0.1
Festuca spp.			2		1					1	1	10		38	1.2
Tiarella laciniata	0.5			2				0.5					2	31	0.4
Adenocaulon bicolor		5			2			3		2	1		1	46	1.1
Blechnum spicant	10			0.5		1					2		5	38	1.4
Maianthemum dilatatum	20			5	1	15	5		10	15	3		3	69	5.9
Athyrium filix-femina	20	20	10	2		5	3		1		2	5	2	77	5.4
Tiarella trifoliata	10	3	5	10	3	20	40	10	30	2	5	5	10	100	11.8
Polystichum munitum	30	50	30	30	30	10		10	30	10	60	5	10	92	23.5
Cinna latifolia			1								0.5			15	0.1
Moneses uniflora									0.5					8	0.1
Angelica sp.												2		8	0.1
Streptopus roseus	0.5	1		2		10	0.5		0.5				1	54	1.2
Gymnocarpium dryopteris				5		10	1						5	31	1.6
MOSSES AND LIVERWORTS															
Polytrichum sp.															
Rhacomitrium heterostichum															
Leucolepis menziesii		15	10								10			23	2.7
Kindbergia oregana	2	20			10	5	10	10	2					54	4.5
Mnium spp.	2		10	5	5			10	3	5		20		62	4.6
Marchantia polymorpha												50		8	3.8
Hylocomium splendens	40			40	10	10	20	50						46	13.1
Rhytidiadelphus loreus	40	5	30	5	20	30	40	5	45	10	10			85	18.5

[1]Plot numbers with a "T" suffix are from the Tahsish Study Area; those with an "A" suffix are from the Artlish Study Area. The letters "C" and "MC" represent constancy (total frequency/no. of releves) and mean cover respectively.
[2]Nomenclature of vascular plants is after Taylor and MacBryde (1977). For the mosses, nomenclature is after Crum, Steere and Anderson (1973) and for liverworts after Stotler and Crandall-Stotler (1977).

(*Thuja plicata*), Western Thimbleberry (*Rubus parviflorus*), Salmonberry, Sitka Willow (*Salix sitchensis*), Red Alder (*Alnus rubra*), Sitka Spruce, Wild Rye Grass (*Elymus* spp.), Wall-lettuce (*Mycelis muralis*) and *Rhacomitrium heterostichum*. Colonization consists of scattered individuals with very low cover values. These plant species once established, help to stabilize the site and promote aggradation (Orloci 1965). The accumulation of a layer of sand results in the increase of already established species and appearance of others. These include Common Yarrow (*Achillea millefolium*), Common Harebell (*Campanula rotundifolia*), Small-leaved Montia (*Montia parvifolia*), Common Cat's-ear (*Hypochaeris radicata*), Common Pearly Everlasting (*Anaphalis margaritacea*), Sitka Columbine (*Aquilegia formosa*), Sweet-scented Bedstraw (*Galium triflorum*), Hair Grass (*Agrostis* sp.) and Common Self-heal (*Prunella vulgaris*). Within ten years Red Alder, Sitka willow, Wild Rye Grass, Wall-lettuce and *Rhacomitrium heterostichum* become the dominant plants. Plant species which occur only in the pioneer seral stage include Common Harebell, Small-leaved Montia, Purple-leaved Willow-herb (*Epilobium ciliatum*), Wild Strawberry (*Fragaria virginiana*), Common Yarrow, Common Cat's-ear and Common Pearly Everlasting.

Young seral floodplain vegetation is characterized by a continuous tree cover of Red Alder with substantial regenerating Sitka Spruce. The high constancy of Red Alder and its nitrogen-fixing ability is a significant factor in soil fertility improvement. The shrub layer is usually dominated by Salmonberry with lesser amounts of Red Alder and Stink Currant (*Ribes bracteosum*). Common herbs include Sweet-scented Bedstraw, Youth-on-age (*Tolmiea menziesii*), Cooley's Hedge-nettle, False Bugbane (*Trautvetteria caroliniensis*), Alaska Onion Grass (*Melica subulata*), Trifoliate-leaved Foamflower (*Tiarella trifoliata*) and Western Sword Fern (*Polystichum munitum*).

A number of plants absent in the pioneer seral stage appear initially in the young seral stage. These species, which are only able to establish under the cover of the Red Alder canopy, include Pacific Bleedingheart (*Dicentra formosa*), Alpine Enchanter's-nightshade (*Circaea alpina*), Weak Blue Grass (*Poa marcida*), Siberian Spring Beauty (*Claytonia sibirica*), False Bugbane, Alaska Onion Grass, buttercup (*Ranunculus* spp.), Northern Maidenhair Fern (*Adiantum pedatum*), fescue (*Festuca* sp.), Trailplant (*Adenocaulon bicolor*), Common Lady Fern (*Athyrium filix-femina*), Trifoliate-leaved Foamflower and Western Sword Fern. Plants which occur in the pioneer seral stage and with increased frequency and cover in the young seral stage include violet (*Viola* sp.), Sweet-scented Bedstraw, Youth-on-age and Cooley's Hedge-

nettle. *Rhacomitrium heterostichum* has completely disappeared in the young seral stage. Mosses which flourish on the shaded forest floor include *Leucolepis menziesii, Kindbergia oregana, Mnium* spp., *Hylocomium splendens* and *Rhytidiadelphus loreus.*

Mature climax forests on the floodplain are dominated by Sitka Spruce, Western Hemlock (*Tsuga heterophylla*), with occasional Big-leaf Maple (*Acer macrophyllum*) and Western Red Cedar. Almost absent from the tree layer is Red Alder. The shrub layer is still predominantly composed of Salmonberry, as a result of the open tree canopy (mean 40% cover). Other common shrubs are Stink Currant, Red Huckleberry (*Vaccinium parvifolium*) and Alaskan Blueberry (*Vaccinium alaskaense*). Dominant herbs include Sweet-scented Bedstraw, Cooley's Hedge-nettle, Alpine Enchanter's-nightshade, False Bugbane, Two-leaved False Solomon's-seal (*Maianthemum dilatatum*), Common Lady Fern, Trifoliate-leaved Foamflower and Western Sword Fern.

A few plant species appear initially in the stable plant community of the mature climax stage. They include Red Huckleberry, Alaskan Blueberry, Simple-stemmed Twistedstalk (*Streptopus roseus*) and Oak Fern (*Gymnocarpium dryopteris*). Notable species which increase in cover from the young seral to the mature climax stage, include Sitka Spruce, Western Hemlock, Sweet-scented Bedstraw, Fescue, Trail-plant, Deer Fern (*Blechnum spicant*), Two-flowered False Solomon's-seal, Common Lady Fern, Trifoliate-leaved Foamflower and Western Sword Fern. Salmonberry maintains a high frequency and cover in the mature climax stage. Species which decrease in cover from the young seral to the mature climax stage include Red Alder, Youth-on-age, Cooley's Hedge-nettle, Wild Rye Grass, Alpine Enchanter's-nightshade, Alaska Onion Grass and Nodding Semaphore Grass (*Pleuropogon refractus*). The moss layer composition is virtually the same in the young seral and mature climax stages, although some cover values are significantly different. *Leucolepis menziesii, Kindbergia oregana* and *Mnium* spp. decrease in cover while *Hylocomium splendens* and *Rhytidiadelphus loreus* increase.

TABLE 2. Characteristic plant species and associated mean cover values for floodplain successional stages

	Successional Stages		
Plant Species	Pioneer Seral	Young Seral	Mature Climax
Alnus rubra[1]	8.6	40.4	.4
Picea sitchensis[2]	1.7	8.5	25.4
Rubus spectabilis	0.4	39.1	35.3
Vaccinium parvifolium			7.5
Vaccinium alaskaense			7.2
Achillea millefolium	0.3		
Hypochaeris radicata	0.6		
Anaphalis margaritacea	0.6		
Aquilegia formosa	0.5	.1	
Elymus spp.	2.5	4.1	.2
Galium triflorum	0.3	1.4	1.8
Tolmiea menziesii	0.1	14.2	3.1
Stachys cooleyae	0.2	14.5	11.4
Circaea alpina		5.3	3.9
Trautvetteria caroliniensis		3.8	2.3
Blechnum spicant		0.2	1.4
Maianthemum dilatatum		2.0	5.9
Athyrium filix-femina		1.0	5.4
Tiarella trifoliata		2.8	11.8
Polystichum munitum		12.0	23.5
Streptopus roseus			1.2
Gymnocarpium dryopteris			1.6
Rhacomitrium heterostichum	3.0		
Leucolepis menziesii		9.5	2.7
Kindbergia oregana		9.3	4.5
Mnium spp.		15.9	4.6
Hylocomium splendens		7.7	13.1
Rhytidiadelphus loreus		5.4	18.5

[1]Value for Pioneer Seral is from the shrub layer.
[2]Values for Pioneer Seral and Young Seral are from the shrub layers.

Discussion

As shown in Table 2 a number of plant species have variable cover values from one successional stage to another. Common Yarrow, Common Cat's-ear, Common Pearly Everlasting, Sitka Columbine and *Rhacomitrium heterostichum* are characteristic colonizing plant species which do not occur in future successional stages (Sitka Columbine occurs with a very low cover value in the young seral successional stage). A few plants increase cover values from the pioneer seral to the young seral stage, then decrease in the climax stage due to competition pressures. They are Red Alder, Wild Rye Grass, Youth-on-age and Cooley's Hedge-nettle. Sitka Spruce and Sweet-scented Bedstraw occur in all three stages and increase throughout. Salmonberry occurs with a low cover value in the pioneer seral stage but increases rapidly and has high cover values in the young seral and mature climax stages. Plants which appear in the young seral stage and decrease in cover value in the mature climax stage are Alpine Enchanter's-nightshade, False Bugbane, *Leucolepis menziesii, Kindbergia oregana* and *Mnium* spp. The plant species which appear in the young seral stage and increase in cover value in the mature climax stage are typical of rich climax ecosystems on the west coast of Vancouver Island. They include Deer Fern, Two-flowered False Solomon's-seal, Common Lady Fern, Trifoliate-leaved Foamflower, Western Sword Fern,

Hylocomium splendens and *Rhytidiadelphus loreus*. Only Simple-stemmed Twistedstalk and Oak Fern occur in the mature climax stage and not in the pioneer seral and young seral stages.

The data illustrate how many of the initial colonizing plants on floodplain gravel bars quickly disappear as the plant communities develop. Only a few species actually occur in the pioneer seral, young seral and mature climax stages and most of these decrease in cover. Most of the plants which establish in the shade of the young seral Red Alder forests represent more stable ecosystem conditions and increase cover in the mature climax stage.

Acknowledgments

Thanks are due to D. Maynard for assistance with field work and to R. Ogilvie and J. van Barneveld for review of the manuscript.

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Received 25 April 1983
Accepted 16 July 1984

Seasonal Habitat Use by Sharp-tailed Grouse, *Tympanuchus phasianellus,* on Mixed-grass Prairie in Montana

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Swenson, Jon E. 1985. Seasonal habitat use by Sharp-tailed Grouse, *Tympanuchus phasianellus,* on mixed-grass prairie in Montana. Canadian Field-Naturalist 99(1): 40–46.

Upland grass and upland crops were first and second, respectively, in observed use by Sharp-tailed Grouse (*Tympanuchus phasianellus*) during all seasons. Hardwood draws were used for foraging for fruits and berries in autumn and for buds in winter. Winter use of habitats varied with snow depth; during periods of deep snow, the grouse used hardwood draws more and upland grass and crops less. Upland grass was selected for the placement of arenas. A mosaic of upland grass with Skunkbush Sumac (*Rhus trilobata*) and riparian hardwood draws seemed to comprise optimum habitat; but small upland winter wheat fields interspersed throughout the area and within 500 m of hardwood draws provided an apparently preferred food source.

Key Words: Sharp-tailed Grouse, *Tympanuchus phasianellus*, habitat use, mixed-grass prairie, Montana.

The broad habitat requirements of Sharp-tailed Grouse (*Tympanuchus phasianellus*) vary considerably among the six subspecies (Johnsgard 1973: 305–306). However, few published studies of the year-long use of habitats are available for the various subspecies. Seasonal habitat use throughout the year by Plains Sharp-tailed Grouse (*T. p. jamesii*) was described in the parklands of east-central Alberta (Moyles 1981) and in short-grass prairie in northeastern Montana (Nielsen and Yde 1981), but croplands were not present in those study areas. Sharp-tailed Grouse feed on cereal grains when they are available (Hillman and Jackson 1973). Here I describe habitat use by Plains Sharp-tailed Grouse in mixed-grass prairie interspersed with cereal croplands in east-central Montana.

Study Area

The study area (47°12′N, 104°33′W) was 24 km northeast of Glendive, Montana, and comprised 207 km² adjacent to and south of the Yellowstone River. The climate is continental and semiarid. Elevations vary from 600 m to 800 m. Topographic features are the result of erosion cutting into the sedimentary plains. Uplands are flat to rolling. The "breaks" of Box Elder Creek, which bisects the study area, consist of steep-sided coulees whereas those along the Yellowstone River are more gentle. Creek and river bottoms are flat to gently sloping.

Ten major vegetation types were delineated on the study area, which lies within the mixed-grass prairie (Weaver and Clements 1938: 460–462). Upland grass (43% of the area) was representative of the Western Wheat-grass (*Agropyron smithii*)-Blue Grama (*Bouteloua gracilis*)-Threadleaf Sedge (*Carex filifolia*) type (Hanson and Whitman 1938). Skunkbush Sumac (*Rhus trilobata*) was common on hillsides within this type. Silver Sagebrush (*Artemisia cana*) grasslands (16%) occurred on bottomlands and in many swales on the uplands (sagebrush type of Hanson and Whitman 1938). Badlands (12%) were steep, sparsely-vegetated south and west slopes, that corresponded to Brown's (1971) Shadscale Saltbush (*Atriplex confertifolia*)-Big Sagebrush (*Artemisia tridentata*) community. Hardwood draws (6%) occurred in mesic coulees where vegetative composition and abundance varied with hydrology and topography. Boxelder (*Acer negundo*) was indicative of the type, and Silver Buffaloberry (*Shepherdia argentea*), American Plum (*Prunus americana*), Green Ash (*Fraxinus pennsylvanica*), and American Elm (*Ulmus americana*) were common. Juniper breaks (3%), an arid type dominated by Rocky Mountain Juniper (*Juniperus scopulorum*), were typically found along deeply eroded draws. Riparian woodland (7%) was restricted to the islands and flood-plains of the Yellowstone River and included dense stands of Plains Cottonwood (*Populus deltoides*), American Elm, and Green Ash. Understory shrubs were abundant. Upland crops (7%) consisted of dryland cereals, almost exclusively winter wheat, farmed in strips and mostly distributed in a mosaic pattern of relatively small (< 65 ha) fields. Bottomland crops (4%), in the river valley, were dominated by dryland and irrigated cereals, again mostly winter wheat. Irrigated hayfields (1%) included alfalfa and introduced grasses along the river bottom. The rose-snowberry type (1%) occurred on the river bottom and islands, and also in small isolated patches at the heads of coulees. It was characterized by dense stands of Wood's Rose (*Rosa woodsii*) and Western Snowberry (*Symphoricarpos occidentalis*).

Methods

From November 1976 through November 1977, I searched the area for grouse from a vehicle and on foot, with and without the use of a dog (English setter). The number, habitat type, activity and location were reported for each observation of Sharp-tailed Grouse. Lekking males and grouse feeding on wheat at a trapsite were not included in the analysis of habitat use. An attempt was made to visit the habitats in relation to their occurrence, but, because the grouse were not equally observable in each habitat type, the data were examined for seasonal changes in use and relative importance rather than for absolute amount of use. For this reason, preference indices were not calculated for the habitats.

The areas of habitats were measured from a 1:24 000 scale habitat map prepared from false color infrared aerial photographs (1:80 000). The habitat map was verified by ground checks. The areas of habitats within 1 km of arenas were also measured from this map with a manual planimeter.

To determine the importance of habitats to the grouse for foraging, autumn food habits were sampled by analyzing the contents, by volume, of 28 crops of grouse taken by hunters on or immediately adjacent to the study area. The use of trees and shrubs in winter was recorded whenever Sharp-tailed Grouse were observed foraging in them. Grouse which were "probably feeding" (those flushed suddenly from the branches of trees or shrubs, not those thought to be using shrubs for cover) were recorded separately.

Snow depth data were obtained from records of the U.S. Department of Commerce weather station in Sidney, 53 km northeast of the study area and also adjacent to the Yellowstone River. It was the closest weather station with continuous snow depth data. I believe that the snow depth data from Sidney reflected conditions on the study area, because no topographical features separated the areas and because winter storms move along broad fronts on the eastern Montana prairies.

Division of the year into seasons followed Moyles (1981): spring 1 April to 15 June; summer, 16 June to 31 August; autumn, 1 September to 15 November; and winter, 16 November to 31 March.

Results and Discussion

Sharp-tailed Grouse showed habitat selection during all seasons. Although habitat use varied seasonally, the upland grass and upland crops habitat types were important during every season (Table 1).

During spring, the great majority of grouse observations were in upland grass, which received its greatest use during that season (Table 1). Upland crops was the only other type receiving significant use. That use was concentrated in stubble from the previous year before it was plowed. An increase in use of upland grass and corresponding decrease in the use of upland crops occurred during April (Figure 1). This corresponded with new growth of forbs and may have been a response to the availability of green forbs, an important spring food (Hillman and Jackson 1973), on the grassland. Grass green-up and the onset of lekking activities, which both began in early March, apparently did not influence habitat use of nonlekking grouse (Figure 1).

An analysis of habitat types within 1 km of 13 arenas indicated that only upland grass and badlands occurred near arenas more commonly than on the study area as a whole. Upland grass was included within 1 km of all arenas (Table 2). The amount of ungrazed or lightly grazed native grasslands and hay-

TABLE 1. Seasonal use of habitats by Sharp-tailed Grouse on mixed-grass prairie in Montana, based on 2861 observations of grouse.

Habitat Type	Occurrence on Area (%)	Percentage of observations by season: Spring (N = 460)	Summer (N = 257)	Autumn (N = 399)	Winter (N = 1745)
Upland grass	43	72 (s)[a]	65	57 (s)	37 (s)
Upland crops	7	20 (s)	24 (s)	16 (s)	34 (s)
Hardwood draws	6	2	2 (s)	12	12 (s)
Silver sagebrush grassland	16	5	8	12 (s)	2 (s)
Bottomland crops	4	0	0	1 (s)	11 (s)
Juniper breaks	3	1	0	2	1
Riparian forest	7	0	0	0	2
Badlands	12	0	0	0	tr
Rose-snowberry	1	0	tr[b]	0	0
Irrigated hayfields	1	0	0	0	0

[a](s) denotes that the use of habitats differed significantly ($P < 0.05$, X^2 test) between seasons.
[b]tr = trace (< 0.5%)

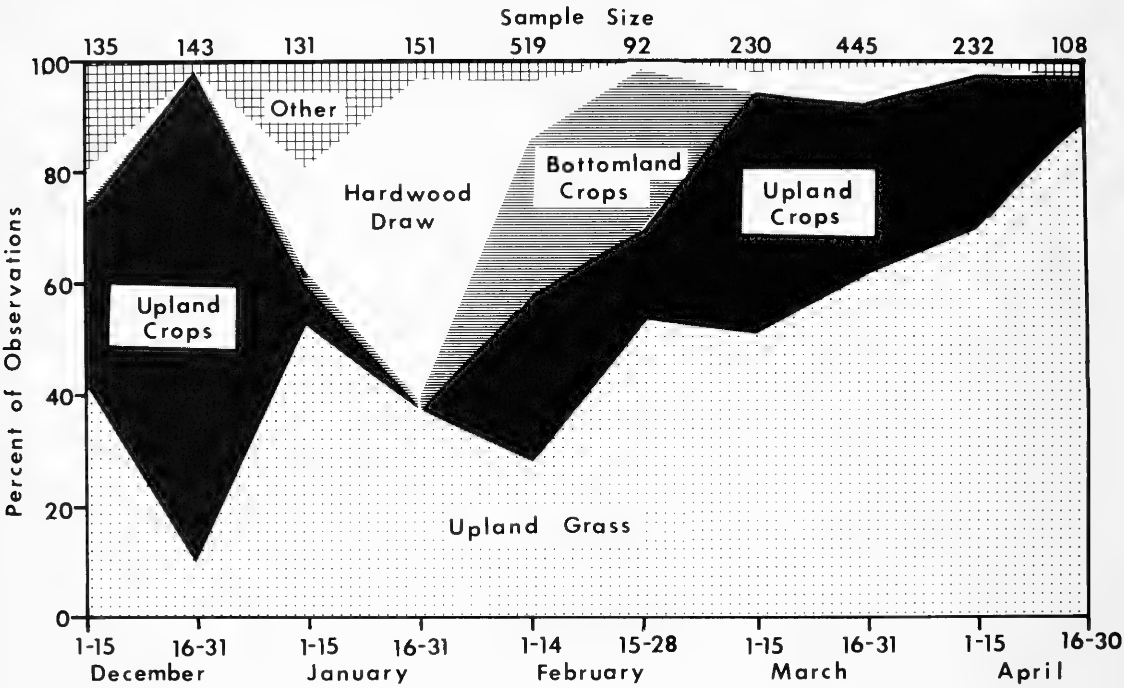

FIGURE 1. Habitat use by Sharp-tailed Grouse in eastern Montana during semimonthly periods in winter and spring (lekking grouse excluded).

lands within 1.6 km of areas was proportional to the number of lekking males on the arenas in Saskatchewan (Pepper 1972). The number of lekking males on my study area was not significantly correlated with the proportion of any habitat, but a negative correlation between number of lekking males and proportion of the hardwood draw type within 1 km was marginally significant ($R = -0.506$, $P = 0.094$). Moyles (1981) found that number of lekking males was inversely related to total coverage of Trembling Aspen (*Populus tremuloides*) within 0.8 km of arenas in the Alberta parklands.

Use of habitats in summer was similar to that in spring (Table 1). The summer use of croplands was primarily in new stubble following combining.

Habitat use in autumn was more diverse than in either spring or summer, but few significant differences were found (Table 1). Although upland grass and upland crops were once again the most important types for Sharp-tailed Grouse, more than 10% of the

TABLE 2. Comparison of habitat types within 1 km of 13 Sharp-tailed Grouse arenas with those of the entire study area.

Habitat Type	Occurrence near arenas		Occurrence on entire area (%)	Selection Index[a]
	Mean (%)	Frequency (%)		
Upland grass	75	100	43	1.7
Badlands	15	69	12	1.2
Hardwood draws	4	62	6	0.7
Upland crops	3	38	7	0.4
Silver Sagebrush grassland	2	31	16	0.1
Juniper breaks	1	23	3	0.3
Riparian forest	0	0	7	0
Bottomland crops	0	0	4	0
Irrigated hayfields	0	0	1	0
Rose-snowberry	0	0	1	0

[a] Ratio of occurrence near arenas to occurrence on the study area.

TABLE 3. Autumn food habits of Sharp-tailed Grouse on the study area, based on 28 crops collected between 24 September and 27 October 1977.

Food	Percent of Total: Volume	Percent of Total: No. of Items	Percent Frequency
Russian Olive (*Elaeagnus angustifolia*)	30	9	21
Currant (*Ribes* sp.)	13	9	29
Chokecherry (*Prunus virginiana*)	12	11	4
Juniper (*Juniperus* spp.)	8	3	21
Rose (*Rosa* spp.)	6	4	11
Subtotal fruits and berries	69	36	64
Wheat	21	37	61
Barley	1	1	4
Subtotal grains	22	38	64
Common Dandelion (*Taraxacum officinale*)	2	2	32
Grass (mostly *Poa* spp.)	2	9	11
Western Sorrel (*Rumex acetosella*)	1	3	7
Littlepod False Flax (*Camelina microcarpa*)	tr[a]	2	4
Juniper (*Juniperus* sp.)	tr	1	4
Skunkbush Sumac (*Rhus trilobata*)	tr	3	4
Alfalfa (*Medicago sativa*)	tr	1	4
Salsify (*Tragopogon dubius*)	tr	2	4
Unknown leaves	tr	1	7
Wooley Groundsel (*Senecio canus*)	tr	1	7
Sweet Clover (*Melilotus* sp.)	tr	tr	4
Subtotal leaves	5	25	64
Cricket parts	4	1	4
Grasshopper parts	tr	tr	4
Subtotal Orthoptera	4	1	7
Wood particles	tr	tr	7

[a] tr = trace (< 0.5%)

observations occurred in each of the Silver Sagebrush grassland and hardwood draw types. Fruits and berries were available in hardwood draws and field observations indicated that forbs remained succulent longer in the more mesic hardwood and sagebrush draws.

A volumetric analysis of crop contents (Table 3) indicated that fruits and berries dominated the autumn diet, followed by domestic grains. This suggested that the grouse increased their use of hardwood draws in autumn because of the availability of fruits and berries. However, 64% of the crops contained green leaves, and leaves comprised almost one-quarter of the number of items found in the crops, indicating that forbs were also important. The high occurrence of Russian Olive was surprising in view of its scarcity on the study area. However, Evans and Dietz (1974) found that Russian Olive was highly preferred by Sharp-tailed Grouse.

Habitat use in winter was markedly different from that in the other seasons, as the grouse made four significant changes in use of habitats from autumn to winter and five from winter to spring (Table 1). During winter, Sharp-tailed Grouse also showed the greatest diversity of habitat use (Table 1). Only during this season were they observed regularly on the valley floor. Upland grass received its least amount of use during winter, whereas upland crops received its greatest use, as did bottomland crops and hardwood draws.

Habitat use during winter varied with snow depth (Table 4). Use of upland grass was greatest at the least snow depth and declined significantly at greater depths. At snow depths greater than 140 mm, Sharp-tailed Grouse fed in bushes, primarily Skunkbush Sumac, while in the upland grass type. Moderate snow depths (66–140 mm) may have triggered greater use of croplands, but use declined significantly and rapidly with increasing snow depth because grain

TABLE 4. The effect of snow depth on use of three habitat groups by Sharp-tailed Grouse during winter on the study area.

	Snow depth (mm)[a]			
Habitat groups	0–65 (N = 651)	66–140 (N = 449)	141–240 (N = 447)	> 240 (N = 198)
Upland grass	47[b] (s)[c]	26 (s)	36	29
Bottomland and upland crops	44 (s)	70 (s)	37 (s)	9
Hardwood draw and riparian forest	7[d] (s)	2 (s)	19 (s)	57

[a]Snow depths from the weather station at Sidney, Montana.
[b]Percent of observations.
[c](s) denotes that the use of habitats changed significantly ($P < 0.05$, X^2 test) between snow depth categories.
[d]This value is high owing to higher use of trees by the grouse in March with little or no snow cover. If the March data were omitted, this value would be 2% and not significantly different from the 66–140 mm category, and no other P values in the table would change.

became unavailable. Conversely, use of the hardwood draw and riparian forest types increased significantly and rapidly as snow depths exceeded 140 mm. The data suggested that wheat fields were favored for foraging in winter by Sharp-tailed Grouse, especially during periods of moderate snow depth, perhaps because waste grain was predictably available there and was relatively abundant. The grouse appeared to be forced from the croplands to the trees and shrubs by deep snow. The wooded riparian habitats were critical for food during deep snow conditions. That snow depth forced grouse from the fields was supported by the following observations: soon after I placed 45 kg of wheat on an abandoned feeding area in a field in late January, a flock of 70 Sharp-tailed Grouse began feeding there. On 1 and 2 February, 43 grouse were captured, leaving 27, but 57 were observed there on 14 February. The snow was deep (> 140 mm) during that entire period. Marshall and Jensen (1937) also found that Columbian Sharp-tailed Grouse (*T. p. columbianus*) fed primarily on wheat in winter and spring in Utah when snow depths were low, but that they shifted to buds when snow depths increased. Schmidt (1936), however, concluded that Prairie Sharp-tailed Grouse (*T. p. campestris*) in Wisconsin used grain in the autumn until the first snow of winter and again in the spring, but not during the winter budding season.

Although croplands appeared to be preferred over hardwood draws by foraging Sharp-tailed Grouse in winter, they only used croplands which were adjacent to hardwood draws. Only 23% of the area of upland crops was within 500 m of a hardwood draw, but 90% of the Sharp-tailed Grouse observed on upland crops (N = 600) were within 500 m of a hardwood draw, significantly different ($P < 0.005$, X^2 test) than the expected distribution. All grouse and 36% of the upland cropland were within 750 m of a hardwood draw. Similarly, 91% of the Sharp-tailed Grouse observed on bottomland crops (N = 176) and 27% of these croplands were within 500 m of hardwood draws. The observed distribution of Sharp-tailed Grouse was again significantly different from the expected distribution ($P < 0.005$, X^2 test). The remaining Sharp-tailed Grouse on bottomland crops were either within 500 m of riparian forest or within 750 m of hardwood draws; 41% of bottomland crops were within 750 m of hardwood draws. The hardwood draws probably provided important escape cover for Sharp-tailed Grouse foraging in grainfields in winter, besides being an important food source. The grouse almost always flew to hardwood draws when flushed from grainfields.

During winter, fruits were available only on rose, Russian Olive and junipers; buds were consumed from other trees and shrubs. Silver Buffaloberry, Skunkbush Sumac, Russian Olive and Creeping Juniper (*Juniperus horizontalis*) were the most important trees and shrubs to foraging grouse, comprising two-thirds of the observed use (Table 5). The crop of an adult Sharp-tailed Grouse killed by a predator on 23 February 1977 contained Buffaloberry terminal twigs with buds, wheat kernels, chokecherry buds and Skunkbush Sumac buds, in decreasing order of importance.

The croplands on the river valley floor were only used to an appreciable extent in February (Figure 1). The bottomland crops were located below and adjacent to the hardwood draws and received use by grouse after the snow depths declined enough so they could leave the hardwood draws in favor of croplands. However, the grouse had abandoned the valley croplands in favor of the upland crops and grasslands by the end of February (Figure 1).

Although cropland was found to be an important habitat to Sharp-tailed Grouse in my study, the conversion of prairie to cropland has been identified as a factor in the decline and extinction of Sharp-tailed

TABLE 5. Feeding by Sharp-tailed Grouse on trees and shrubs during winter on the study area.

Species	Feeding observed (N = 308)	Probably feeding (N = 87)	Combined (N = 395)
Buffaloberry (*Shepherdia argentea*)	21[a]	36	25
Skunkbush Sumac (*Rhus trilobata*)	22	1	18
Russian Olive (*Elaeaghus angustifolia*)	16	3	13
Creeping Juniper (*Juniperus horizontalus*)	15	0	12
Rose (*Rosa* spp.)	9	1	8
Rocky Mountain Juniper (*Juniperus scopulorum*)	4	20	7
Chokecherry (*Prunus virginiana*)	0	30	7
Common Juniper (*Juniperus communis*)	4	0	3
Plains Cottonwood (*Populus deltoides*)	2	6	3
Boxelder (*Acer negundo*)	3	2	2
Snowberry (*Symphoricarpos occidentalis*)	1	0	1
Green Ash (*Fraxinus pennsylvanicus*)	1	0	1
Willow (*Salix* sp.)	1	0	1
American Elm (*Ulmus americana*)	0	1	tr[b]

[a] Percent
[b] tr = trace (< 0.5%)

Grouse in many parts of its range (Buss and Dziedzic 1955; Brown 1966; Miller and Graul 1980). I rarely observed Sharp-tailed Grouse in grainfields more than 50 m from the edge. Thus, the conversion of large blocks of prairie to cropland would be detrimental to the grouse because they use only the edges of fields.

Seasonal habitat use by Sharp-tailed Grouse on my study area was generally similar to that reported by Moyles (1981) from south-central Alberta and by Nielsen and Yde (1981) from northeastern Montana. Many of the differences among the areas were due to habitat availability and reflected adaptation by the grouse to local conditions. In all these areas, grouse showed a high degree of use of grasslands and deciduous trees and shrubs. In my area, cereal cropland (primarily winter wheat) also received a high level of use. In winter, Sharp-tailed Grouse fed mainly on aspen buds in Alberta (Moyles 1981) and primarily on Silver Buffaloberry buds in northeastern Montana (Nielsen and Yde 1981). Winter foods were more varied on my area owing to the presence of wheat and more tree and shrub species, but buffaloberry was also the most important tree/shrub. The very low use of upland grass in winter by grouse in northeastern Montana (Nielsen and Yde 1981) may have been related to the few shrubs (particularly Skunkbush Sumac) in that type there. In both Alberta and northeastern Montana tree and shrub communities received a high level of use by grouse in spring, in contrast to the low amount of use documented on my area. This may have been due to the availability of grain on my area, which the grouse seemed to prefer over buds.

No birds were marked during this study, but it appeared that the Sharp-tailed Grouse exhibited local migrations to use preferred habitats. This was most evident in winter with large numbers appearing in croplands near hardwood draws, the appearance of grouse in trees on the riverbottom, and their sudden appearance on and disappearance from bottomland crops in the late winter. Valley bottoms were not used by Sharp-tailed Grouse during other seasons. The hardwood draws were restricted to a narrow band between the uplands and the valley, at the edge of the spring-fall range of the Sharp-tailed Grouse. The suggested movements may have exceeded 5 km.

Moyles (1981) concluded that a mosaic of plant communities, particularly grasslands and grassland-shrub mixtures with extensive ecotone, provides optimum habitat for Sharp-tailed Grouse in Alberta parklands. My results generally supported that conclusion for Sharp-tailed Grouse in mixed-grass prairie in Montana. Optimum habitat there consists of a mosaic of upland grassland with Skunkbush Sumac and riparian hardwood draws. Upland cereal cropland (primarily winter wheat) provided an apparently preferred food source when it occurred in a mosaic pattern of small fields interspersed throughout the area and within 500 m of hardwood draws. However, it would be detrimental if it occurred in large blocks because the grouse only foraged at the edges of fields. In addition to large-scale farming, overgrazing represents a threat to Sharp-tailed Grouse on the mixed-grass prairie (Brown 1966; Pepper 1972; Kirsh et al. 1973; Nielsen and Yde 1981). Also, the hardwood draws concentrate cattle in summer and the hardwood vegetation is very susceptible to damage by cattle overgrazing (Benke and Raleigh 1979; Boldt et al. 1979; Swenson 1981). Thus, overgrazing by cattle

could severely damage this critical habitat for Sharp-tailed Grouse on mixed-grass prairie.

Acknowledgments

I thank P. Herzog, R. L. Eng, R. R. Martinka, and L. S. Nielsen for their constructive comments on the manuscript and K. Taylor for measuring the crop contents. This study was funded by Intake Water Company, Inc., under contract with the Montana Department of Fish, Wildlife and Parks and under the direction of R. R. Martinka.

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Received 22 April 1983
Accepted 30 January 1984

Radiant Surface Temperatures and Hair Depths of a Black Bear, *Ursus americanus*

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Moen, Aaron N., and Lynn Rogers. 1985. Radiant surface temperatures and hair depths of a Black Bear, *Ursus americanus*. Canadian Field-Naturalist 99(1): 47–50.

Radiant surface temperatures of a Black Bear (*Ursus americanus*) vary with ambient temperature; four linear regression equations are used to predict radiant temperatures on the head, neck, belly, and trunk. The trunk, with the greatest hair depth, is the coldest; predicted radiant temperature is about -2° C when air temperature is -10° C. Head temperatures are highest, and more variable than trunk and neck temperatures. A curled-up bear minimizes surface area while exposing deep trunk hair to ambient conditions.

Key Words: Black Bear, *Ursus americanus*, Radiant temperature, temperature isopleths, hair depth isopleths.

The radiant temperature of an animal's surface is a function of the ambient energy load, metabolic heat production, and the effectiveness of the pelage as thermal insulation. In cold weather, well-insulated mammals have low, and poorly-insulated animals have high, radiant temperatures as metabolic heat is dissipated. Radiant temperatures are reflections of the overall insulation of the pelage, and of differences in both insulation per unit depth and total depth of the hair.

Every animal is constantly exchanging radiant heat energy with its surroundings. Calculated energy budgets should include radiant energy estimates, either as part of a summation procedure or as an integral part of an overall heat transfer coefficient. This paper includes predictive equations for the relationships between ambient temperature and radiant temperatures of the body, neck, and head of a Black Bear (*Ursus americanus*), with additional data on measured hair depths of the bear.

Methods

Radiant temperatures were measured with a Barnes Instatherm hand-held radiant thermometer on the head, neck, body and belly of a 132 kg wild-trapped male black bear in a 5 x 5 m pen from 4 November–5 December 1981. Ambient temperatures ranged from +15 to -15C, with little or no wind. The bear had been removed from its den and caged on 28 October. Temperature measurements were made when the bear was sleeping, resting but awake, and moving about the cage. An audible seeker assisted in determining the highest radiant temperature reading for a body part. Radiant temperatures analyzed by regression included only those recorded when the bear was in diffuse light and infrared radiation. A few measurements made on sunlit hair are discussed separately.

The bear was immobilized on 5 December and a detailed radiant temperature profile made by scanning the entire body at close range. During these measurements, ambient temperature ranged from -3° to -4° C, and there was no wind. Hair depths were also measured by reading a small ruler where hair densities occluded the mm graduations, which was about 10 mm from the tips of the longest guard hairs and about 1 mm from the tips of the short hairs on the feet and muzzle.

Results and Discussion

Linear regression equations were derived for X = ambient temperature (T^a) and Y = radiant temperature (T^r) of the head, neck, trunk, and belly. The data were first analyzed separately for active, resting, and sleeping readings, but the slopes of the lines for all activities were statistically similar (t test, 0.05 level) so the data for these activities were combined.

The equations for the radiant temperature: air temperature relationships (Figure 1) are:

Head: $T^r = 14.41 + 0.50T^a$; $R^2 = 0.55$, N = 56
Neck: $T^r = 9.86 + 0.55T^a$; $R^2 = 0.96$, N = 9
Belly: $T^r = 12.15 + 0.69T^a$; $R^2 = 0.78$, N = 6
Trunk: $T^r = 6.09 + 0.77T^a$; $R^2 = 0.96$, N = 60

The low R^2 values for the head indicate differences in radiant temperatures of the nose, mouth, eyes, muzzle and hair-covered parts of the head. The high R^2 values for the neck and trunk indicate uniformity in the radiant temperatures of these large target areas.

Radiant temperature isopleths (Figure 2) determined from scanning at close range illustrate the differences over the surface of the bear. The close-up temperatures on the body were about 3° C higher than the temperatures predicted with the regression equations, perhaps due to excitement and muscle activity of the bear prior to immobilization, and also to the recording of the highest temperature indicated for the small close-up target area. Note the variability over the muzzle, eye, and other areas of the head; close-up

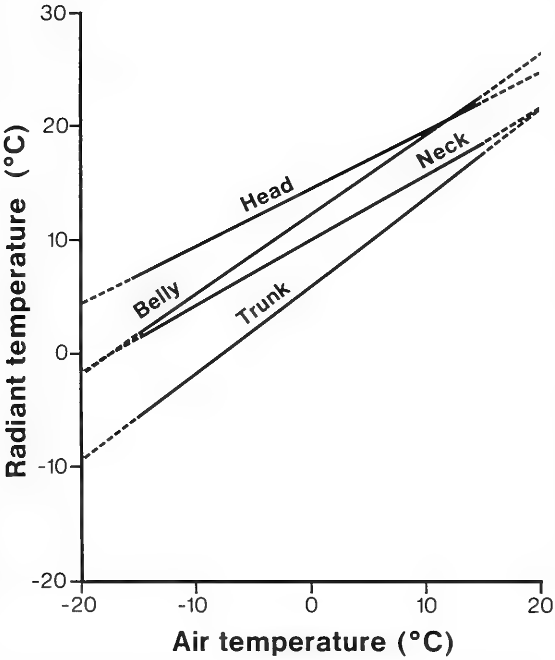

FIGURE 1. Regression lines expressing the relationships between air temperature and radiant temperature of the hair of a black bear. Equations and R^2 values are given in the text.

scanning reveals the effects of differences in hair depths and target characteristics.

Radiant temperatures of the neck and torso were quite predictable with linear regression equations. The linear relationship between T^r and T^a has been characteristic of all such measurements made by A.N.M. on a variety of mammals (Moen 1973, 1974; Moen and Jacobsen 1974; Moen 1984). The high R^2 values for the neck and trunk equations are reflections of uniformity over rather large areas. Hair depths for these parts, while variable, were also quite deep (Figure 3), resulting in low variability in radiant temperature readings. The low R^2 values for the head equations are due to greater variability in hair depths and to difficulty in determining actual target areas. There was a steep temperature gradient from the thin-haired muzzle (22° C) to the thicker-haired cheek (8° C) when close-up measurements were made on the immobilized bear (Figures 2 and 3).

Radiant temperatures of the belly also were higher and more variable than on the trunk and neck. The long but sparse hair (Figure 3) presented a variable target which in some cases included exposed skin, depending on the lie of the hair during temperature measurements.

A few radiant temperature measurements were made when the fur was exposed to sunlight. In one instance, with an ambient temperature of 2°, the radiant temperature of the trunk on the sunlit side was 34° C. On the shaded side it was 8°, about as predicted by the regression equation for the trunk. Other recorded radiant temperatures on sunlit fur on the trunk were 37° at T^a = 13°, and 26° at T^a = -1° C. These high radiant temperatures are not unlike temperature patterns A.N.M. has observed on sunlit hair of black angus and on the black hair of holstein cattle; sunlit readings of over 50° occurred at summer temperatures around 25° C (unpublished data).

Morse (1937) and Svihla and Bowman (1954) observed that snow accumulated on the backs of some black bears sleeping on open ground in winter. Data for the bear measured in this study predict that a radiant temperature of 0° should occur at an ambient temperature of -8° C. Ambient temperatures below -8° should result in snow accumulation on the bear. Svihla and Bowman (1954) reported a thermocouple-measured hair surface temperature of 0° when ambient temperature was about -7.8° C, very close to the radiant temperature predicted with the trunk equation.

Radiant temperatures on the belly, feet, and head are higher than on the back (see Figure 2). A curled-up sleeping bear not only minimizes surface area, but also exposes a maximum amount of well-insulated hair surface to ambient conditions.

Comparison of data for the bear with data reported for White-tailed Deer *(Odocoileus virgianus)* (Moen 1973, 1974) indicate that insulation of the bear's winter coat was superior to that of deer. At an ambient temperature of -30°, predicted T^r on the trunk of the bear is -17°, whereas on a white-tailed deer it is -12° C in no wind.

Acknowledgments

This work was completed at the North Central Forest Experiment Station's Kawishiwi Field Laboratory in the Superior National Forest while A.N.M. was on sabbatical leave from Cornell University, Ithaca, New York. Research on Black Bears and on the energetics of homeotherms is sponsored by the USDA — Forest Service, North Central Forest Experiment Station, by the New York Department of Environmental Conservation through P-R project W-124-R, and the New York State College of Agriculture and Life Sciences, Hatch Project 406.

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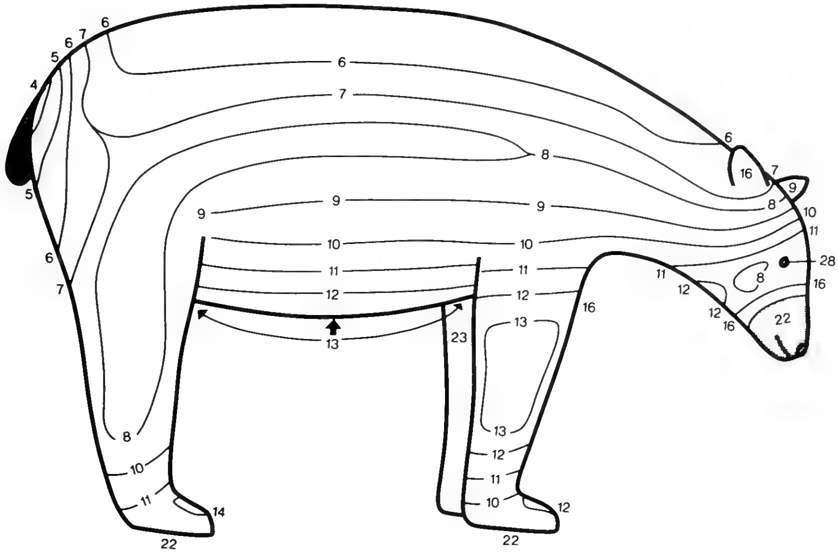

FIGURE 2. Radiant temperature isopleths based on close-up scanning of an immobilized bear exposed to an ambient temperature of −3 to −4° C.

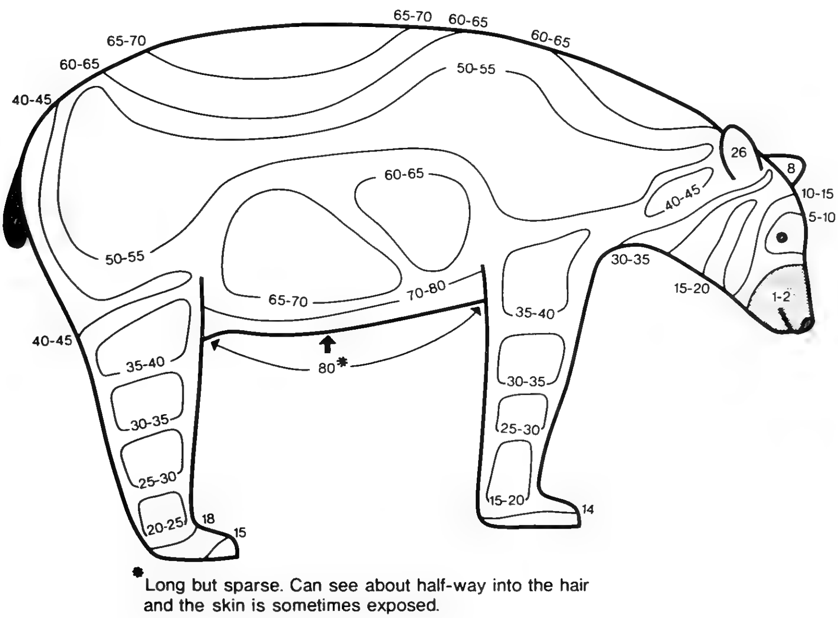

FIGURE 3. Hair depth isopleths (cm) based on measurements on an immobilized bear.

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Received 28 April 1983
Accepted 13 June 1984

Population Fluctuations in the Small Mammals of the Kluane Region, Yukon Territory

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Krebs, Charles J., and Irene Wingate. 1985. Population fluctuations in the small mammals of the Kluane Region, Yukon Territory. Canadian Field-Naturalist 99(1): 51–61.

From 1973 to 1977 we studied population changes in small rodents of the Kluane Lake region, southwestern Yukon. Six species were at maximal abundance in 1973 and were relatively scarce from 1974 to 1977. Only one species, *Microtus oeconomus* (Tundra Vole), showed a correlation between body size and population size (the Chitty Effect). Reproductive rates varied among species but were not related to population density in any species. *Peromyscus maniculatus* (Deer Mouse) had the lowest reproductive rate because of a short breeding season, so that females had only one or two litters in most years. There was no evidence of winter breeding in any species. We conclude that none of the small rodent species in the Kluane region, except *Microtus oeconomus*, show good evidence of 3–4 year population cycles. Density fluctuations are irregular and populations appear to be strongly *r*-selected in an unfavourable environment which is typically almost empty of rodents.

Key Words: population fluctuations, cycles, rodents, Yukon, Deer Mouse, *Peromyscus maniculatus*, Northern Red-backed Vole, *Clethrionomys rutilus*, Tundra Vole, *Microtus oeconomus*, Meadow Vole, *Microtus pennsylvanicus*, Heather Vole, *Phenacomys intermedius*, niche overlap, r-selection

An area of high diversity of microtine rodents in North America occurs in the mountains of the Yukon and Alaska (Hawes 1975). Although several surveys have been done in this area (Rand 1945; Baker 1951; Banfield 1961; see also Youngman 1975), there are no long-term data on population changes in the small rodents of the southern Yukon. From 1973 to 1977 we studied the small mammals of the Kluane Region, and we present here data on the population dynamics of the five most common small rodents.

Methods

This study was done in the area surrounding Kluane National Park in the boreal forest of the southwestern Yukon (as described in Krebs and Wingate 1976). The basic sampling technique used was a line of snap traps, 20 stations spaced at 15.2 m intervals in a straight line with three traps per station. Museum Special snap traps were used. Each line was left in position for three days and checked daily. Parallel lines were set out at least 61 m apart. Peanut butter was used as bait. The same general areas were trapped each year, although we were unable to place traps at exactly the same stations between years. Sampling was carried out from April to September each year.

All rodents captured were autopsied. We used the standard methods of autopsy as described in Keller and Krebs (1970). Females were classified as nulliparous, primiparous, or multiparous. Normal and resorbing embryos were counted. We did not try to count corpora lutea, corpora albicantia, or placental scars. Average number of litters per female was calculated as in Caughley (1977, page 79).

Habitat was classified around each snap-trapping station. It was difficult to place a trap line entirely within a single habitat. Our habitat classification followed Douglas (1974) but grouped some communities into a simpler classification. Krebs and Wingate (1976, Table 1) list the habitats sampled and the plant communities they contained.

Because not all the species occur in every habitat, we calculated indices of abundance for specific habitats. For *Peromyscus* six habitats were included: aspen, balsam poplar, balsam poplar-buffaloberry, willow, open spruce, and closed spruce. For *Clethrionomys* seven habitats were included — all of the *Peromyscus* habitats plus subalpine shrub tundra. For *Microtus pennsylvanicus* two habitats were included: marsh and shrub birch-meadow. For *Microtus oeconomus* three habitats were used: alpine tundra, subalpine shrub tundra, and marsh. For *Phenacomys intermedius* five habitats were used: aspen, balsam poplar, balsam poplar-buffaloberry, shrub-birch-meadow, and willow.

Results

Relative Abundance

We caught ten species of mice and voles in our snap traps; Table 1 gives the total catch and relative abundance for each species over the five years of study. *Peromyscus maniculatus* and *Clethrionomys rutilus* were the two dominant species every year; *Microtus pennsylvanicus* was a distant third, comprising an average of 8% of the catch. These three dominants together comprised 85–98% of the total catch over the five years. The other seven species were rare and usually comprise less than 5% of the catch, averaging only 1.3% each. These patterns of relative abundance fluctuated slightly from year to year but were remarkably stable.

TABLE 1. Total catch and relative abundances (%) of the ten species of voles and mice caught in snap-trap lines in the Kluane Region, 1973–1977.

Species	1973	1974	1975	1976	1977	Total
Peromyscus maniculatus Deer Mouse	369 (46.4)	129 (26.2)	255 (34.1)	288 (51.7)	266 (51.7)	1307 (42.1)
Clethrionomys rutilus Northern Red-backed Vole	293 (36.9)	202 (41.1)	369 (49.3)	192 (34.5)	215 (41.7)	1271 (40.9)
Microtus pennsylvanicus Meadow Vole	23 (2.9)	88 (17.9)	64 (8.6)	52 (9.3)	23 (4.5)	250 (8.0)
Microtus oeconomus Tundra Vole	50 (6.3)	11 (2.2)	14 (1.9)	5 (0.9)	6 (1.2)	86 (2.8)
Phenacomys intermedius Heather Vole	6 (0.8)	17 (3.4)	9 (1.2)	7 (1.3)	3 (0.6)	42 (1.4)
Microtus miurus Singing Vole	14 (1.8)	26 (5.3)	30 (4.0)	2 (0.4)	0	72 (2.3)
Microtus longicaudus Long-tailed Vole	35 (4.4)	10 (2.0)	4 (0.5)	6 (1.1)	1 (0.2)	56 (1.8)
Synaptomys borealis Northern Bog Lemming	1 (0.1)	4 (0.8)	2 (0.3)	0	0	7 (0.2)
Lemmus sibiricus Brown Lemming	0	4 (0.8)	0	1 (0.2)	0	5 (0.2)
Zapus hudsonicus Meadow Jumping Mouse	4 (0.5)	1 (0.2)	1 (0.1)	4 (0.7)	1 (0.2)	11 (0.4)

Population Density

Relative population density was estimated by the index of snap-trapping catch (number of animals per 100 trap-nights). Two major sources of variability are present in these data. Area effects occur because not all the Kluane Region operates in synchrony (see Krebs and Wingate 1976, p. 382). Temporal effects should be easier to visualize. None of these rodents has been found to breed during the winter. Thus population density should fall to its minimum in the spring or early summer, and then rise to a seasonal peak in later summer or early autumn.

Area effects were present, as described previously (Krebs and Wingate 1976), but the patterns of density changes over the five years were the same in all areas. One exception was Jacquot Island in Kluane Lake which was first trapped in the summer of 1977 and had very high densities of *Peromyscus, Clethrionomys* and *Microtus pennsylvanicus* at that time. For this reason we have lumped together data from all the Kluane Region (except Jacquot Island) in our analysis.

Figure 1 shows the seasonal and yearly variations in *Peromyscus* density from 1973 to 1977. These data fall into two groups: 1973 was a high-density year, and all the other years were low density years. The density in 1974 was particularly low. Numbers had dropped very much from September 1973 to April 1974, so that the high density occurred within one year.

Figure 2 shows the *Clethrionomys* indices for 1973–77. Again 1973 was a year of high density, and like *Peromyscus* none of this carried over into 1974. The autumn density of 1975 was also relatively high but otherwise every year had the same low density, averaging 1.0 individuals or less per 100 trap-nights.

Figure 3 gives the average indices of abundance for three of the less common species. In every case 1973 was a year of peak numbers, and density either declined or stayed low from 1974 to 1977. In contrast to *Peromyscus* and *Clethrionomys*, numbers seemed to decline only slightly from 1973 to 1974 in *Microtus pennsylvanicus* and *Phenacomys intermedius*.

Only one high density population of *Microtus longicaudus* was ever found, in 1973 near Sockeye Lake. *Microtus miurus* was at high density in subalpine and alpine tundra at Coin Creek in August 1975 and 1976. *Microtus miurus* was the only vole which did not seem to fit the pattern of peak density in 1973.

Table 2 summarizes the indices of population size for the five major species for 1973 to 1977. The coefficient of variation (SD/mean) of the average indices is highest for the two rare species and nearly the same for the two most common species.

To summarize: 1973 was the year of maximum

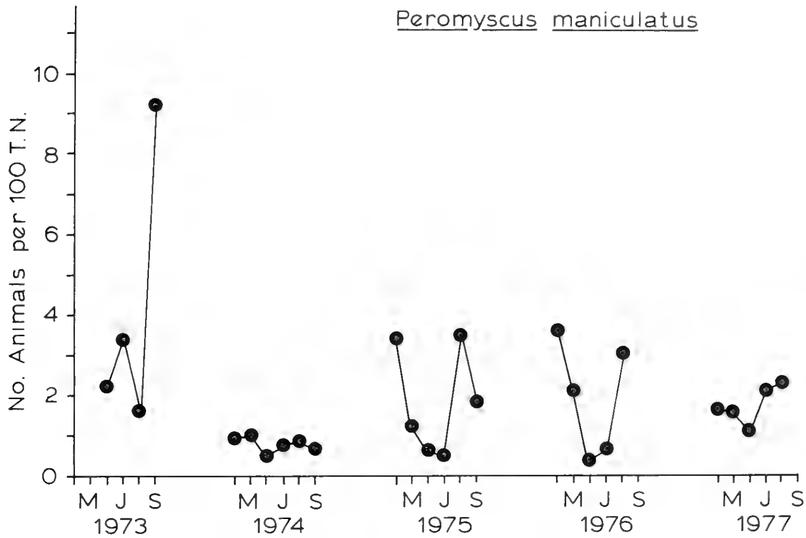

FIGURE 1. Abundance of *Peromyscus maniculatus* in the Kluane region, southwestern Yukon, 1973–1977. Abundance is estimated from snap-trapping of six habitats with samples averaged over months from April to September. T.N. = trap nights.

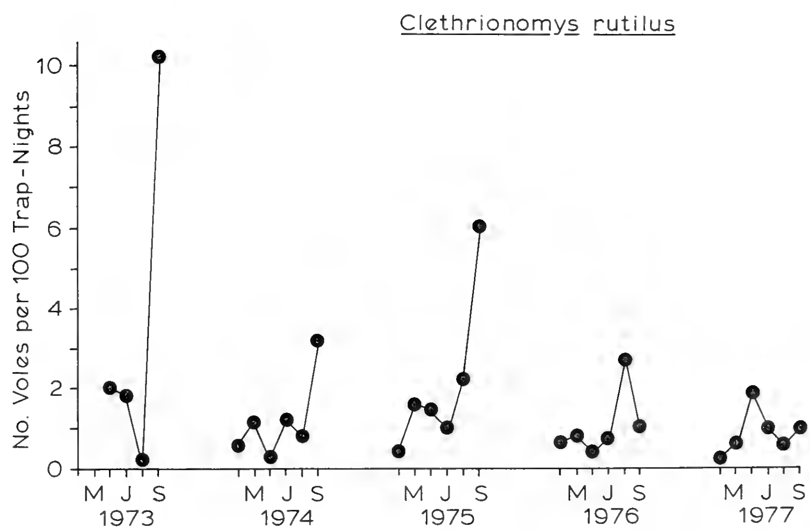

FIGURE 2. Abundance of *Clethrionomys rutilus* in the Kluane Region, 1973–1977. Abundance is estimated from snap-trapping in seven habitats with samples averaged over months from April to September.

TABLE 2. Average index of population size (no. caught per 100 trap nights) for combined samples, April to September. Numbers in parentheses are the number of trap-nights. Mean is the mean of all years. C.V. — coefficient of variation of population size among years (%).

Species	1973	1974	1975	1976	1977	Mean	C.V.
Peromyscus maniculatus	3.88 (7704)	0.86 (15066)	1.55 (16209)	1.52 (18810)	1.58 (16497)	1.87	61.9
Clethrionomys rutilus	2.69 (10224)	1.05 (19287)	2.03 (17649)	0.86 (21384)	1.08 (19377)	1.54	51.0
Microtus pennsylvanicus	2.92 (720)	2.47 (2961)	1.55 (3618)	1.34 (3654)	0.05 (2097)	1.66	66.8
Microtus oeconomus	0.52 (8280)	0.11 (6642)	0.12 (5193)	0.04 (6714)	0.14 (4383)	0.18	103.0
Phenacomys intermedius	0.18 (2745)	0.17 (4023)	0.04 (4509)	0.05 (5481)	0.03 (3519)	0.10	77.6
Total all rodents	4.65 (17100)	2.14 (22950)	3.34 (22365)	2.09 (26604)	2.38 (21609)	2.81 (110628)	

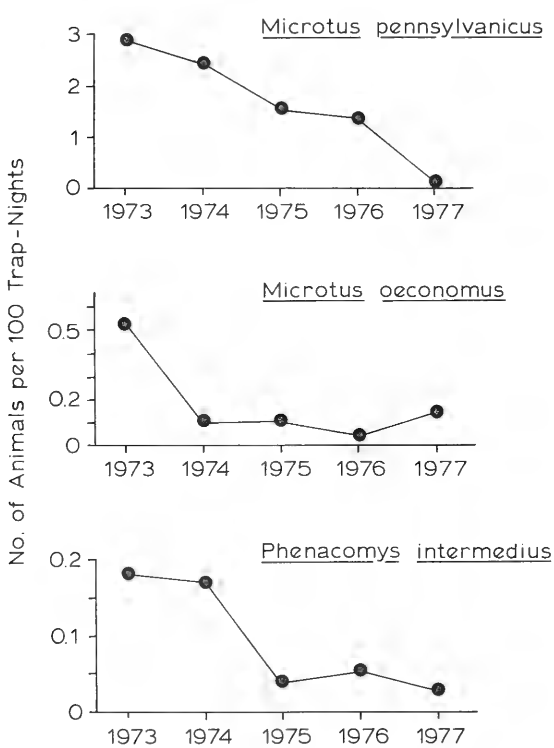

FIGURE 3. Abundance of the less common small rodents in the Kluane region, 1973–1977. *Microtus pennsylvanicus* abundance estimated from snap-trapping in two habitats, *Microtus oeconomus* from three habitats, and *Phenacomys intermedius* from five habitats. See text for details.

density for six of seven species, and numbers were lower in most species from 1974 to 1977.

Body Weight

Voles which fluctuate in abundance in a 3–4 year cycle typically show a cycle in adult body weight. Individuals in peak populations typically are 20–30% larger than individuals in declining or low populations (the Chitty effect; Boonstra and Krebs 1979). We looked for the Chitty effect in our data.

Table 3 gives the mean body weights of males of the four species with sufficient samples in May and June. Only overwintered adults are included in this table. The two dominant species, *Peromyscus* and *Clethrionomys*, showed no variation in average adult size from year to year. In particular, weights of adults were no larger in the high density year of 1973 than they were at other times. In *Microtus pennsylvanicus* there is also no sign of the Chitty effect. The largest male caught in the high density year 1973 was 44 g, compared with 43 g in 1976 and 45 g in 1977 when density was low. In *Microtus oeconomus*, by contrast, the Chitty effect is very clear. In the high density year of 1973 six of 16 breeding males exceeded 42 g, to a maximum of 52 g. In 1974 the largest male was 39 g, in 1975 41 g, in 1976 38 g, and in 1977 34 g.

Reproductive Rate

Table 4 summarizes the reproductive data for *Peromyscus, Clethrionomys, Microtus pennsylvanicus*, and *M. oeconomus* for the years 1973 to 1977. There was no indication of winter breeding for any of these species. No young animals were ever caught until the end of May and reproduction had always ceased by the time trapping stopped in late September or October.

TABLE 3. Mean body weight (g) of overwintered males in May and June (± 1 S.E.).

May	1973	1974	1975	1976	1977
Peromyscus	—	25.3 ±0.5	26.9 ±0.4	25.6 ±0.3	26.0 ±0.5
Clethrionomys	—	23.2 ±0.6	24.7 ±0.3	23.9 ±0.9	22.0 ±0.7
M. pennsylvanicus	—	26.0 ±0.9	23.5 ±4.5	27.0 ±2.6	—
M. oeconomus	—	28.0 ±1.7	22.0 ±2.0	29.5 ±0.5	—
June					
Peromyscus	25.8 ±1.1	23.8 ±1.0	26.5 ±1.1	26.2 ±1.1	25.7 ±1.1
Clethrionomys	19.9 ±1.7	23.9 ±1.8	28.7 ±1.0	25.9 ±1.2	22.8 ±0.5
M. pennsylvanicus	26.8 ±2.4	30.7 ±2.6	33.3 ±0.3	28.5 ±0.5	35.8 ±1.8
M. oeconomus	38.0 ±1.5	32.5 ±1.7	28.3 ±2.6	35.0 ±3.0	29.5 ±2.5

Pregnancy rates were determined for primiparous and multiparous females from the height of the breeding season. Since gestation periods in all these species range from 19–23 days, and embryos can be seen macroscopically only after five days of pregnancy, the theoretical maximum pregnancy rate should be 0.74 to 0.78 when every female is pregnant all the time. Observed rates in Table 4 are nearly all in the 0.6 to 0.7 range, and this is consistent with a model of continuous maximal reproduction of mature females with either a post-partum oestrous or an estrous cycle 4–5 days after parturition. When adult females are breeding, they seem to be doing it at a maximal rate.

Litter sizes do not vary significantly between primiparous and multiparous females, except in *Clethrionomys rutilus*. All four species seem to have an average litter size between five and six. We could detect no seasonal variation in litter size, but this may be a result of our small sample size.

The most striking difference between these species is in the length of the breeding season. *Peromyscus* has a very short breeding period, about half of the length of *Clethrionomys*. In some years (1973, 1975) most *Peromyscus* females could have only one or two litters, and none of the young mice bred during their first summer. The potential number of young produced per mature female averages only 14 in *Peromyscus*, compared with 28 in *Clethrionomys*. The two *Microtus* species are intermediate with potential production of 19–23 young per female.

Variations in the average number of litters produced set an upper limit to population growth in these species. With 100% survival *Peromyscus* populations could go up only 7-fold in one year, while *Clethrionomys* populations could increase 14-fold as a maximum. It would be surprising if the annual survival rate was as high as 50%, and we would expect the actual rate of increase to be approximately 3–4-fold in *Peromyscus*, 7-fold in *Clethrionomys*, 5–6-fold in *Microtus pennsylvanicus*, and 4–5-fold in *M. oeconomus* at best.

Table 5 gives the median weights at sexual maturity for *Clethrionomys, Microtus pennsylvanicus*, and *M. oeconomus* samples trapped in July and August each year. Weight or age at sexual maturity is one of the parameters most responsive to density changes in small rodents (Krebs and Myers 1974). Surprisingly, none of these species showed any year-to-year variation in size at maturity. In particular, none of the high density 1973 populations appeared to exhibit an increased size at maturity. We did not calculate median weight at maturity for *Peromyscus* because no young mice ever reached maturity in their first summer of life.

Niche Breadth

Different species of rodents in the Kluane Region occupy a variable habitat range (Krebs and Wingate 1976). *Peromyscus* and *Clethrionomys*, for example, occur in many different habitats whereas *Microtus* spp. are typically found in only a few. We quantified the range of habitats used by calculating standardized niche breadth (Pianka 1973) using the 18 habitat types listed in Krebs and Wingate (1976, p. 380). Table 6

TABLE 4. Reproductive rate estimates for *Peromyscus*, *Clethrionomys*, *Microtus pennsylvanicus*, and *M. oeconomus* for 1973–1977. Sample sizes in parentheses. F = female, M = male. Litter size: P = primiparous, M = multiparous.

Species	Year		Length of Breeding Season			Pregnancy Rate	Litter Size	% Embryos Resorbing	Ave. No. Litters per Female	Potential No. of Offspring
			Date Start	Date End	Days					
Peromyscus	1973	F	?	24 June	—	0.40(5)	6.5 (2)	7.1 (14)	—	—
		M	?	4 July	—					
	1974	F	17 May	14 July	58	0.62(8)	5.6 (7)	11.3 (44)	2.26	14.7
		M	29 April	2 July	65					
	1975	F	7 May	24 June	48	0.60(20)	5.8 (12)	1.4 (71)	1.80	10.1
		M	28 April	8 July	72					
	1976	F	30 April	17 July	79	0.71(38)	5.3 (14)	3.9 (77)	3.50	20.3
		M	24 April	23 July	90					
	1977	F	15 May	19 July	65	0.64(36)	5.8 (27)	3.1 (163)	2.60	15.1
		M	24 April	19 July	86					
	Mean	F	9 May	9 July	62	0.64(107)	5.71(62)	4.33(369)	2.48	14.2
		M	26 April	11 July	77					
Clethrionomys										
	1973	F	?	26 August	—	0.65(48)	P 5.6 (11)	2.3 (214)	—	—
		M	?	16 September			M 6.2 (24)			
	1974	F	30 April	5 September	129	0.60(30)	P 5.6 (23)	0.5 (193)	4.84	29.8
		M	28 April	10 September	136		M 6.3 (10)			
	1975	F	4 May	2 September	122	0.63(43)	P 5.8 (22)	1.9 (267)	4.80	29.0
		M	28 April	1 September	127		M 6.1 (22)			
	1976	F	30 April	12 August	111	0.72(36)	P 4.7 (13)	6.6 (197)	5.00	30.7
		M	24 April	20 September	150		M 6.5 (19)			
	1977	F	26 April	9 August	110	0.55(47)	P 5.7 (9)	1.2 (171)	3.78	22.9
		M	24 April	9 September	139		M 6.2 (19)			
	Mean	F	30 April	23 August	116	0.63(204)	P 5.50(78)	2.50(1042)	4.57	27.8
		M	26 April	11 September	139		M 6.25(94)			

TABLE 4. (concluded)

Species	Year		Length of Breeding Season			Pregnancy Rate	Litter Size	% Embryos Resorbing	Ave. No. Litters per Female	Potential No. of Offspring
			Date Start	Date End	Days					
Microtus pennsylvanicus										
	1973	F	?	29 August	—	0.69(13)	4.1 (9)	2.6 (38)	—	—
		M	?	1 September	—					
	1974	F	16 May	5 September	113	0.74(57)	5.2 (43)	2.2 (230)	5.23	27.2
		M	11 May	5 September	118					
	1975	F	26 May	20 August	87	0.57(14)	5.9 (8)	0.0 (47)	3.10	18.3
		M	11 May	13 September	126					
	1976	F	10 May	18 August	101	0.63(30)	4.7 (19)	9.2 (98)	3.98	18.7
		M	1 May	29 September	152					
	1977	F	?	?	—	1.00(8)	5.7 (8)	0.0 (46)	—	—
		M	?	8 September	—					
	Mean	F	17 May	26 August	102	0.70(122)	5.09(87)	3.27(459)	4.46	22.7
		M	8 May	11 September	127					
Microtus oeconomus										
	1973	F	?	21 August	—	0.78(9)	5.1 (11)	3.4 (58)	—	—
		M	?	29 August	—					
	1974	F	16 May	1 August	77	0.50(16)	5.4 (11)	4.8 (62)	2.41	13.0
		M	10 May	21 August	104					
	1975	F	23 May	21 September	122	0.50(10)	4.9 (8)	9.3 (43)	3.81	18.7
		M	11 May	13 September	126					
	1976	F	?	?	—	1.00(1)	7.0 (1)	0.0 (7)	—	—
		M	25 April	?	—					
	Mean	F	18 May	25 August	100	0.58(36)	5.19(31)	5.29(170)	3.63	18.8
		M	5 May	31 August	119					

TABLE 5. Median body weights (g) at sexual maturity for voles caught during July and August, 1973–1977.

	Males		Females	
	Median	95% C.L.	Median	95% C.L.
Clethrionomys rutilus				
1973	19.5	18.5–20.4	20.1	19.1–21.1
1974	19.0	17.9–20.0	19.4	17.7–21.2
1975	17.8	16.8–18.7	17.8	16.2–19.4
1976	16.8	15.8–17.9	20.2	19.0–21.5
1977	19.0	17.3–20.7	21.9	20.0–23.9
Microtus pennsylvanicus				
1973	20.8	18.4–23.5	17.9	15.4–20.7
1974	19.5	18.0–21.1	16.4	12.0–22.3
1975	19.4	14.9–25.4	19.9	14.7–27.0
1976	20.4	18.5–22.5	19.0	17.5–20.6
1977	18.0	16.1–20.1	20.4	16.6–24.9
Microtus oeconomus				
1973	25.5	24.0–27.1	20.6	16.8–25.4
1974	21.1	19.9–22.4	20.3	15.6–26.4
1975	22.4	19.7–25.4	21.3	16.8–27.1

gives these niche breadths for 1973 to 1977. Two points of interest emerge from this table. First, niche breadths were remarkably stable from year to year in spite of the variations in population density. Second, two groupings of species fall out of Table 6. The common species *Peromyscus* and *Clethrionomys* had equal and broad niches. The rare species, all *Microtus*, had narrow niches.

As with niche breadth, niche overlap in these rodents seems to remain relatively constant from year to year. Table 7 gives the average values of niche overlap for the 6 most common species. Only two values are noticeably high. *Peromyscus* and *Clethrionomys* overlapped greatly in their range of habitats occupied, and *Microtus pennsylvanicus* and *M. oeconomus* also had high overlap.

Discussion

Population cycles are commonly believed to be a characteristic feature of small rodents in northern ecosystems, and the first question we must address is whether the populations we have studied in the Kluane region of the Yukon show any evidence of cycles. We used three criteria to decide if a population is cyclic:

(1) peaks in density should recur at 3–4 year intervals;
(2) during population peaks mean body weights of overwintered adults are increased 20–30%; and
(3) reproductive rates are increased in expanding populations and reduced in declining populations.

All of these criteria are flexible because some exceptions occur to the classical cyclic syndrome (Krebs and Myers 1974).

From the density criterion, none of the five species shown in Figures 1–3 is cyclic. For an interval of five years we expect to see two population peaks, but only one possible 'peak' could be described — 1973. For the two dominant species (*Peromyscus* and *Clethrio-*

TABLE 6. Standardized niche breadths of small rodents sampled by snap trapping in 18 habitats, 1973–1977.

	1973	1974	1975	1976	1977	Mean
Peromyscus maniculatus	0.40	0.42	0.51	0.46	0.52	0.46
Clethrionomys rutilus	0.33	0.39	0.61	0.26	0.56	0.43
Microtus pennsylvanicus	0.07	0.12	0.16	0.09	0.12	0.11
Microtus oeconomus	0.24	0.13	0.19	0.11	0.09	0.15
Microtus miurus	0.12	0.12	0.06	0.11	—	0.10
Phenacomys intermedius	0.14	0.42	0.26	0.21	0.15	0.24
Microtus longicaudus	0.19	0.16	0.11	0.23	0.06	0.15

TABLE 7. Average niche overlap for seven small rodent species in the Kluane area. Values based on a mean of five values calculated for each year 1973–1977.

	Clethrionomys rutilus	*Microtus pennsylvanicus*	*Microtus oeconomus*	*Microtus miurus*	*Phenacomys intermedius*	*Microtus longicaudus*
Peromyscus maniculatus	0.51	0.05	0.16	0.06	0.26	0.31
Clethrionomys rutilus		0.15	0.08	0.02	0.20	0.27
Microtus pennsylvanicus			0.46	0.02	0.27	0.06
Microtus oeconomus				0.08	0.35	0.14
Microtus miurus					0.12	0.12
Phenacomys intermedius						0.29

nomys) the evidence is stronger because Gilbert and Krebs (1981) give two further years of live-trapping data for these species, and we have further unpublished data for 1980–83. Since 1973 there has been no high density of either *Peromyscus* or *Clethrionomys* for nine years. We are thus confident that neither of these species shows population cycles in the Kluane region. We are less confident in this conclusion for the *Microtus* species. Five-year cycles are not unknown among microtines and a five-year cycle could explain the results shown in Figure 3. Furthermore, we have observed outbreaks of *Microtus* in local areas in the Kluane region while doing other studies. For example, *Microtus pennsylvanicus* was abundant on Jacquot Island in Kluane Lake in the summer of 1977, and *Microtus* spp. were also seen there commonly in 1980.

Except for *Microtus oeconomus*, none of the species studied showed the body weight change characteristic of many cyclic small rodents (Krebs 1964). On this evidence we would classify *M. oeconomus* as cyclic in the Kluane area. We are surprised that *M. pennsylvanicus* seems to show no change in body weight of adults from year to year. Our samples, while small, are adequate to detect this striking effect if it occurred.

Finally, none of the species showed any sign of variation in reproductive rates that seems characteristic of many cyclic populations. Sample sizes are small for *Microtus oeconomus*, but we could detect no striking changes in the length of the breeding season or in the size at sexual maturity. These two components of reproduction change dramatically in most cyclic populations (Krebs and Myers 1974). We conclude that none of the rodent species in the Kluane region except *Microtus oeconomus* shows evidence of cycles in numbers. For *M. oeconomus* the evidence is weak but suggestive of cycles. We interpret the density changes shown in Figures 1–3 as irregular fluctuations.

Fuller (1969) studied *Peromyscus maniculatus* and *Clethrionomys rutilus* populations near Great Slave Lake, 1100 km east of our study area. He found high populations of *Peromyscus* in 1961 and 1966, and high populations of *Clethrionomys rutilus* in 1962 and 1967. Fuller (1969) observed no change in body weight of adults from year to year, a conclusion in agreement with our findings.

Martell and Fuller (1979) compared *Clethrionomys rutilus* populations in taiga and tundra areas near Inuvik, N.W.T. They found no winter breeding in either habitat. There was no sign of a population cycle in the tundra population and only a modest 4–fold fluctuation in spring densities in the taiga population. Martell and Fuller (1979) reported larger litter sizes for their populations. Whereas our mature females had litters averaging 6.25, their taiga females averaged 6.7–7.1, and their tundra females 7.3–7.9. But most of their females produced only two litters a year whereas our *Clethrionomys* averaged four or five litters a year. Thus overall production of young is higher in our population because of a longer breeding period.

Koshkina and Korotkov (1975) summarized 15 years of data on *Clethrionomys rutilus* populations in central Siberia. Our *Clethrionomys* populations never seemed to reach the high densities reported by Koshkina and Korotkov (1975). It is difficult to compare results directly but our densities appear to be only one-quarter those of Koshkina and Korotkov (1975). Furthermore, our populations showed much less year-to-year fluctuation. Spring densities varied less than 4–fold in our populations, but 7–10–fold in

Koshkina and Korotkov's populations. Whereas the summer peak in numbers was very similar in the Siberian populations (2–3–fold variation), it was more variable in our populations (5–6–fold variation). In years of high density Koshkina and Korotkov (1975) found a reduction in the maturation rate of young-of-the-year voles, so that the percentage of young voles sexually mature was inversely related to population density. We did not observe this effect in our *Clethrionomys rutilus* data because young voles mature every summer at the same size.

Whitney (1976) studied sympatric populations of *Clethrionomys rutilus* and *Microtus oeconomus* near Fairbanks, Alaska, about 640 km northwest of our study area. He trapped three populations for four years and found that *Clethrionomys* attained the same density every autumn, while *M. oeconomus* showed a population cycle with peaks three years apart. These results conform closely with our findings. Whitney (1976) postulated that population cycles were characteristic of species with narrow niches, and his hypothesis is supported by our data (Table 6). Whitney's hypothesis predicts that all our *Microtus* species and *Phenacomys* should show population cycles. Because of their low abundance we cannot definitely reject this prediction for our *Microtus* spp. We can, however, see no way of reconciling Whitney's hypothesis with Koshkina and Korotkov's (1975) data on *C. rutilus*.

Millar et al. (1979) analyzed latitudinal variation in reproduction in *Peromyscus*, and commented on the shortage of data from high latitude populations. Their data predict an average litter size of 5.93 for our populations, compared with our observed value of 5.71, and they predict a breeding season of 86 days compared with our observed 62 days for females. Our data are much closer to Fuller's (1969) values than they are to the predictions of Millar et al. Our *Peromyscus* are atypical because no young-of-the-year reach maturity during their first summer, which thus eliminates the most important component Millar et al. (1979) identified as increasing summer productivity. Millar and Gyug (1981) also reported that *P. maniculatus* from Hay River, N.W.T., did not reach sexual maturity until one-year old. *Peromyscus* appear to be unique among the small rodents of the Kluane area because it shows traits of a K-selected species — short breeding season, slow rate of maturation, large body size, and relatively constant population density.

We interpret all the voles in the Kluane region to be under extreme r-selection and thus selected for maximal reproductive rates in an unfavourable environment. The high mortality over the prolonged winter non-breeding season reduces the population every year to levels approaching local extinction. Population fluctuations result from changes in mortality rates in the face of a constant high reproduction. The most striking feature of these small mammal communities is that they are close to being empty most of the time. The selective premium is always on individuals trying to fill up a largely empty world, and we would predict competition for food both within and between species to be minimal.

More experimental work needs to be done on these northern populations to try to identify the factors limiting population sizes. We have already tried to increase population size by supplemental feeding (Gilbert and Krebs 1981). Manipulations designed to improve overwinter losses are badly needed. Fuller (1977) has rejected the hypothesis that variations in winter losses are determined by differences in winter weather conditions in the subnivean environment for *Clethrionomys gapperi*, so more complex hypotheses are needed. Year-to-year fluctuations in these Yukon populations are produced by events in the winter, non-breeding period and not determined by variations in reproductive success during the summer months.

Acknowledgments

We thank Gary MacIsaac, Scott Gilbert, Michael Moult, Kathy Hanson, Suzanne Robertson, Chris Perrin, Bud Muller, Jeff Green, Ray Hilborn, Judith Anderson, Jim Redfield, Janice LeDuc, Tom Sullivan, Mary Taitt, and Daphne Fairbairn for their help with the field work. This research was supported by funds from the Arctic Institute of North America and the Natural Science and Engineering Research Council of Canada.

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Received 25 May 1983
Accepted 17 August 1984

Status of the Great Blue Heron, *Ardea herodias*, in Ontario

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Dunn, Erica H., David J. T. Hussell, and Joanne Siderius. 1985. Status of the Great Blue Heron, *Ardea herodias*, in Ontario. Canadian Field-Naturalist 99(1): 62–70.

The status of the Great Blue Heron (*Ardea herodias*) in Ontario was determined, with the help of volunteers, through an inventory of colony locations and counts of nests in colonies. A complete census was attempted in three census areas in which there were 83 known colonies with an estimated 4583 pairs. Nest counts were made in 147 colonies throughout the province and the sizes of 54 more colonies were estimated. A minimum of 13 022 pairs of Great Blue Herons is estimated to have nested in at least 376 colonies in Ontario in 1980 and 1981. The census areas contain an estimated 28–35% of the total breeding population, so the status of an important segment of Ontario's Great Blue Heron population can be monitored through future censusing in those areas alone.

Key Words: Great Blue Heron, *Ardea herodias,* census, population status.

Although Great Blue Herons are large, conspicuous birds that are widely distributed across Ontario, little is known about the status of the species over broad areas of the province. As pollution, wetland drainage, woodlot clearing and other development may affect Great Blue Herons, it was considered desirable to obtain more precise information on the status and distribution of the species and to devise a method for monitoring the future status of the population. Another objective of our study was to develop methods and experience in the deployment of volunteers in wide-scale censusing of nesting birds. The Long Point Bird Observatory (LPBO) coordinated the inventory and census, with cosponsorship by the Ontario Ministry of Natural Resources (OMNR) and the Ontario Region of the Canadian Wildlife Service (CWS).

Methods

Information on locations of colonies was collected during 1978–81. In 1979 a pilot census to test methods was undertaken consisting of nest counts in several colonies. In 1980–81, three large areas ("census areas", Figure 1) were censused by counts from the ground, and aerial searches were conducted as a check on completeness of coverage. Additional counts were also obtained from colonies outside the census areas.

As used here, a "census" is an attempt to count all nests in all colonies in a specified area (the census area) in a specified time interval (the census period). A "count" or "nest count" is an attempt to count all the nests in the colony; "count" always refers to an enumeration of nests and *never* to an enumeration of colonies.

Colony inventory

Information on the locations of colonies was obtained from several sources. Inquiries through radio and newspaper announcements and of naturalists' and sportsmens' groups brought many responses; other data were received from OMNR and CWS personnel, and from the Ontario Nest Records Scheme. Potential contributors were provided with written instructions and standardized data sheets. As much information as possible was recorded by the contributor for each site, including number of nests, land ownership, physical conditions, etc., but current status, size and even exact location were often unknown.

Nest counts and censuses

Volunteer counters for the 1980–81 census period were recruited from the same groups approached for information on locations of heronries. They were provided with background information on colonies assigned to them, written instructions and record forms for counting nests, and flagging tape. Background information included location data and any other information available on the colony (see previous section). Instructions included information on how to classify nest status, based primarily on occupancy and presence of guano "whitewash", and general advice on safety precautions, obtaining permission from landowners and avoidance of disturbance to breeding birds. (Full details available from the authors). Counts were conducted in June, the early to middle chick stage in Ontario. At each nest tree the counter tallied the nests on a field sheet as "active" (in use), "inactive" (definitely not in use), or of "unknown status", and tagged the tree with flagging tape before moving on to the next occupied tree. At the end of the count the tags were removed.

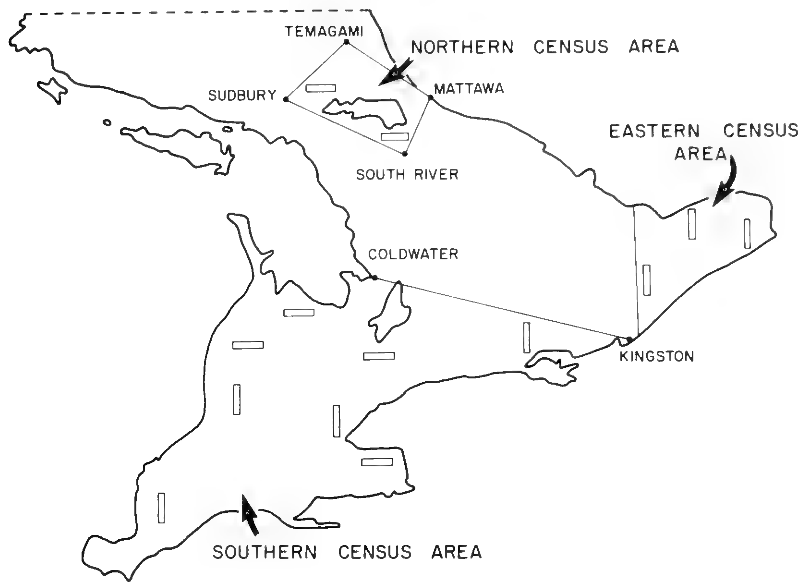

FIGURE 1. Location of census areas and of aerial survey plots (rectangles).

Few counts took more than 1 h, and there was no evidence that the disturbance was harmful to the nesting birds. Some colonies were counted twice by separate parties, to assess inter-party variability. Others were counted both by the above procedure and from aircraft (see below).

Census Areas

A nest count of all heronries in Ontario was deemed unfeasible. Therefore three census areas were selected (Figure 1) in which attempts were made to locate and count every breeding site in 1980 or 1981. Nest counts in colonies in other areas were encouraged, but only if volunteers were available. In 1981, special efforts were made to count nests outside the census areas in the 13 colonies known to contain more than 50 breeding pairs.

The census areas were chosen to represent (1) a sufficiently large area (i.e. containing a sufficient number of colonies) that population size change indicated by future censuses there would reflect the status of a substantial portion of the provincial population, and (2) different geographical regions (on and off the Canadian Shield). The areas also included much of the well-populated area of Ontario, where heron populations are most likely to be affected by human activities. The three census areas combined covered 76 600 km^2 (8.6% of Ontario's land area).

Aerial Surveys

Aerial searches for colonies were conducted within the census areas 19–26 November 1980 to help us estimate the number of colonies in the census areas for which we had received no information in our pre-census inventory. Flights were made over 13 plots, each 6 × 50 km, within the census areas (Figure 1). Plots picked in a random procedure were checked to ensure that they (1) contained no more than 5 linear km of transect over any one body of water, or more than 10% of a plot over urban areas, (2) were no closer than 25 km to a previously chosen plot, (3) were no further than 25 km from an airport. If those criteria were not met, the plot was rejected and another randomly chosen until the desired number had been picked for each census area. Surveys were conducted from a Cessna high-wing aircraft flying at 150 m (300 m above urban areas), at 160 km/h, with two observers (one at each side of the aircraft). Six transects, 1 km apart, were made along the 6 × 50 km plot, and the observers searched for colony sites within ½ km on either side of the flight-line. Each plot required about 2¼ h to complete. The same observers and experienced pilot made all flights. The observers were not aware before the flight whether or not colony sites had been reported from a particular plot. Colony location and size (estimated without leaving the flight-line) were marked on the topographical maps used for navigation.

A second aerial search on 24–25 March 1981 was made specifically to look for colony sites in suitable habitat from which no reports had been received. Almost 3 500 km^2 of habitat were examined, mostly in the eastern and northern census areas. Flight and

recording conditions were as above, but without the plot format. A few colonies were flown over repeatedly to allow as careful a count of nests as possible.

Estimation of total numbers in Ontario

An estimation of total population size of Great Blue Herons in Ontario is important both in determining the province-wide status of the species and in assessing the usefulness of our census areas for monitoring the Ontario population in future. Many of the colonies known to us, however, could not be visited to determine their current size or even whether they were still in use. Through the procedure outlined in Appendices I and II, we have extrapolated data from visited colonies to estimate the size of colonies not yet visited, as well as the proportion likely to be now inactive.

Briefly, the estimation procedure was as follows: If a nest count was done in 1980 or 1981, the most recent figure for colony size was used. For some of those colonies, previous estimates of size had been made. By comparing the estimated size to the subsequent count, a correction factor for estimates was calculated, which was used to adjust the estimated sizes of other, uncounted colonies. Similarly, a correction factor was calculated for counts of nests made outside the breeding season. Lastly, if no size estimate of any sort was available, the average size for that degree of latitude (based on all of the above) was assigned to the colony. Because many colonies become inactive after a few years of use, it is probable that many of the uncounted colonies recorded in our inventory are no longer in use. We calculated the proportion of colonies visited in 1980-81 which had previously been reported as active, but which proved no longer to be so. The total of unvisited "active" colonies in the inventory (see Table 1) was then reduced by this proportion. In all of the above, separate adjustments were made for different regions and colony sizes where those variables gave different correction factors.

All results reported in this paper are based on data available as of 21 August 1981.

Results and Discussion

The status of Great Blue Heron breeding sites known to us is given in Table 1, and Figure 2 shows the distribution of active colonies. In the two-year census period, nest counts were made in 147 colonies and another 54 colonies were visited and their size estimated (Table 2).

A conservative estimate was made of the total pairs of Great Blue Herons nesting in the census areas and in Ontario as a whole (Table 3. See Methods and Appendices for calculation). We estimate a total of 13 022 pairs nesting in the province in 376 colonies, and over half of the pairs were actually counted in 1980–81.

A comparison of our results to those in other (mostly less complete) studies (Table 4) indicates that Ontario's heron population is as large as for any region (and perhaps all combined) in Canada. It remains for future study to determine whether the population is changing in size.

Two questions must be addressed in assessing the reliability of our data in the census areas. First, what proportion of colonies in the census areas is known to us, and second, how accurate are the counts.

In the flights conducted to determine the proportion of colony locations reported to us, no new sites were found in the southern or eastern census areas (out of 0 and 4 colonies found, respectively). In the northern area, the one site located was new. The flight

TABLE 1. Great Blue Heron colonies known to Ontario Heronry Inventory.

	Number of colonies				
Area	Total	Active[1]	Inactive[2]	Extinct[3]	Unknown status[4]
Southern census area	107	47	8	52	0
Eastern census area	30	13	5	12	0
Northern census area	42	23	0	19	0
Census areas combined	179	83	13	83	0
Other areas	510	352	20	57	81
All Ontario	689	435	33	140	81
(% of total)	(100)	(63)	(5)	(20)	(12)

[1]"Active" colonies are those reported since 1975 in which birds were nesting in the year of most recent information.
[2]"Inactive" colonies are those reported since 1975 in which no birds were nesting in the year of most recent information, but which were not known to have been unused for 2 or more years (see footnote 3. Some colonies are known to be reoccupied after a year of disuse).
[3]"Extinct" colonies are those which were (a) reported since 1975 but showed no nesting activity for two or more consecutive years, (b) without information since 1960, (c) known to have been physically destroyed, or (d) not located during 1980 or 1981 after reasonable efforts.
[4]Colonies of "unknown" status are those for which our latest information pertains to the period 1960-1975.

FIGURE 2. Distribution of active Great Blue Heron colonies in Ontario.

TABLE 2. Great Blue Heron nest counts and estimates, 1980-1981.

Area	No. of active colonies[1] Total	with nest count[2]	with size estimate[2]	without count or estimate[2]
Southern census area	47	38 (81)	7 (15)	2[3] (4)
Eastern census area	13	12 (92)	1 (8)	0 (0)
Northern census area	23	19 (83)	4 (17)	0 (0)
Census areas combined	83	69 (83)	12 (14)	2 (2)
Other areas	352	78 (22)	42 (12)	232 (66)
All Ontario	435	147 (34)	54 (12)	234 (54)

[1]See definition in footnote 1 to Table 1.
[2]Percent of total in parentheses.
[3]Both colonies are known to have had herons breeding in 1981.

TABLE 3. Estimated numbers of Great Blue Herons in Ontario (see Appendices).

Area	No. pairs counted[1] (A)	Estimated no. pairs not counted[2] (B)	Estimated total no. pairs (A + B)	Estimated no. active colonies[3]
Southern census area	2507	616	3123	47
Eastern census area	580	71	651	13
Northern census area	745	64	809	23
Census areas combined	3832	751	4583	83
Other areas	3141	5298	8439	293
All Ontario	6973	6049	13022	376

[1]Number nests reported to be in use plus ½ the number whose status could not be determined (DesGranges 1980).
[2]Number of pairs estimated to be present in active colonies not counted in 1980 or 1981. See Appendix I for calculation.
[3]Estimated number of colonies which would have proved to be active had they all been visited in 1980 or 1981 (see Appendix II).

TABLE 4. Comparison of heron numbers and colony densities of various Canadian regions.

Place, year of study	No. active colonies	No. breeding pairs	Average colony size	Breeding pairs per 1000 sq. km[1]	Colonies per 1000 sq. km[1]	Source
Alberta 1980	74	1435	19	2.2	0.1	Brechtel unpublished[2]
Saskatchewan 1970	31	831	27	2.5	0.1	Vermeer and Anweller 1970
Ontario 1980-1981[3]	376	13022	35	22.8	0.7	This study
Quebec 1980-1981	173	4860[4]	28	21.0	0.7	DesGranges and LaPorte 1983
Maritimes 1969-1979	92	3800	33	28.2	0.7	Smith unpublished[5]

[1]Territory north of the breeding range of Great Blue Herons (Godfrey 1966) was eliminated from the density calculations. The following figures were used for estimated breeding range: 15% of Quebec's land area, 50% of Alberta and Saskatchewan, 80% of Ontario and 100% of the Maritimes.
[2]A status report, management proposal and selected bibliography for the White Pelican, Double-crested Cormorant, and Great Blue Heron in Alberta, 1980, *by* S. H. Brechtel. 1981. Alberta Government Department of Energy and Natural Resources, Wildlife Division. 113 pp.
[3]From Table 3.
[4]Total number known colonies times average size of those counted in 1981.
[5]Great Blue Heron colonies in the Maritime Provinces, *by* A. D. Smith. 1980. Environment Canada, Canadian Wildlife Service. 25 pp.

designed to locate new colonies turned up no new colonies in the southern or eastern census areas, but nine in the northern census area. Those results suggested that our inventory for the southern and eastern areas was essentially complete, but that the northern census area is likely to contain colonies as yet unknown to us. That area is relatively small, however, and has small colonies. If we guess arbitrarily that as many as ⅓ of the colonies in that area are still unknown to us, and that they have the same average size as the known colonies, then the total number of nesting pairs in the three census areas would rise by only 9%. Most probably, underestimation from that source is less than 5%.

We next considered the accuracy of the counts. Our only way of assessing the accuracy of nest counting in a colony was to compare counts made by different parties in the same year (Figure 3). Errors in nest counts within colonies may result from (a) omission of some of the nest trees from the count or, (b) miscounts of the number of nests in a tree, or both. Negative errors of both types are more likely to occur than positive errors because it is more likely that nest trees and nests will be missed than nonexistent ones counted. Our recommended procedure of tagging each tree as the nests in it are counted helps the censuser avoid type (a) errors, but in some colonies nesting trees are quite dispersed and our records of the numbers of nest trees in duplicate counts indicated that nest trees were sometimes missed.

Additional data are needed to determine whether error variance changes with colony size; if we assume that it does not, we can pool the data from all duplicate counts to determine the average error. Based on the data in Figure 3, low counts averaged 71% of the high counts. Stated another way, this means that the total of the low counts would have to be increased by 41% to give the same number of nests as the high counts. For the reasons given above, the high counts of each duplicate pair are probably more accurate than the low counts. Assuming that the high counts indicate the true numbers present, the average error for all counts in the set of duplicate counts is of the order of −15% of true colony size. (For colonies not counted, the estimation of colony size, described in Appendix I, depended on extrapolation of data from counted colonies. The errors discussed above, therefore, apply to the estimates from uncounted as well as counted colonies. It should be noted that 84% of all known colonies in the census areas were actually counted).

Thus, our tentative conclusion on the accuracy of the nest counts is that the results may be too low by as much as 15%. Nevertheless, our experience with

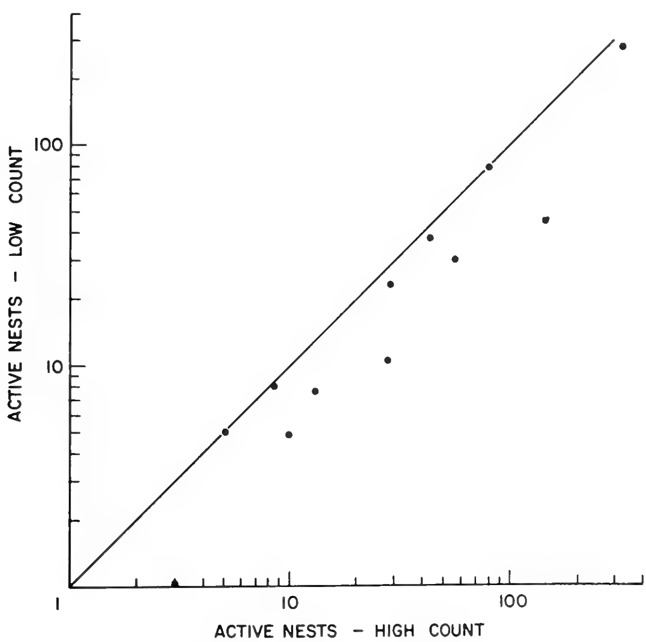

FIGURE 3. Number of active nests in counts completed in the same colony and breeding season by different counters.

volunteer counters and the small number of duplicate counts made lead us to believe that the true error may be much smaller.

Combining our estimates of error resulting from incomplete knowledge of colony sites and from inaccuracy of counts within colonies, we believe that it is very unlikely that we have overestimated the total breeding population within the census areas (Table 3). Assuming ⅓ of colonies in the northern area are unknown to us, and a counting underestimate of 15%, the estimated number of pairs in the census areas would rise to a maximum of 5868.

In practical terms, uncertainty about the magnitude of errors means that difficulties will arise in interpreting differences between this census and any future censuses. Further research should be done on counting error so that more precise confidence limits may be put on nest counts and census results. This, in turn, will allow statistical comparisons of data between years.

Even considering accuracy problems, the census areas are probably adequate for monitoring Great Blue Heron population status for the areas of Ontario where most people live. The minimum and estimated maximum values for pairs nesting in the census areas are 4583 and 5868. The estimate of total pairs in the province, 13 022 (Table 3), is also a minimum. If we revise it upwards, assuming that ⅓ of all colonies outside the southern and eastern sample areas are unknown to us and are the same average size as other colonies in their respective areas, and that all colonies are undercounted by 15%, the estimated maximum number of pairs in Ontario would be 20 760. Thus the proportion of the provincial population within the census areas is 35% based on the conservative estimates in Table 3 or 28% based on the maximum population estimates calculated above. Changes in the census area population should reflect parallel changes in the heron population in similar regions elsewhere in the province, that is, that segment of the population most subject to human pressure.

Despite the high estimates of error in our censuses, we are confident that the method gives the best combination of accuracy and cost effectiveness available. Six nest counts taken from aircraft were lower (compared to ground counts) by more than 50%. Ground counts by professional staff only would require an unreasonably high level of funding, and might not improve results.

Volunteers (162 altogether) were responsible for 73% of counting trips. Nearly half counted nests in more than one colony in a year, and a quarter took part in both years. Volunteers were willing to work diligently, and there was no evidence of harm to nesting birds. We believe that volunteers could be reliably mobilized to complete a new census of the census areas in the future. In addition, the use of volunteers in censusing should have long-term benefits beyond the census period itself, in terms of awareness and protection of local colonies.

Acknowledgments

We thank the many individuals whose generous volunteer efforts made the inventory and census possible. Hans Blokpoel and Philip Taylor (CWS) and Irene Bowman and Gerald McKeating (OMNR) all contributed during the planning stages. OMNR and its district offices made significant contributions to data collection, as did representatives of the CWS and several Conservation Authorities. George Peck provided data from the Ontario Nest Record Scheme. David Fieseler and Terry E. Quinney compiled heronry data in 1978 and 1979, and Quinney organized and conducted the preliminary censuses in 1979. Grant Curtis, Tracy Dean, Jan Vandermeer, Tom Doubleday, Marie Luise Kopp, and Bet Silieff gave field assistance. Our appreciation is extended to Don Fish, pilot, and to Peter Verberg and Chris LeMieux, who acted as observers during the aerial surveys. H. Blokpoel, S. G. Curtis, C. D. MacInnes and G. E. J. Smith gave very helpful advice on clarifying the text, as did reviewers J. Burger and J. L. DesGranges. Support was provided through Contract No. 1SZ80-00052, Department of Supply and Services Canada, CWS (Ontario Region), OMNR (Wildlife Branch and Simcoe District), and the Canadian National Sportsmen's Fund. This paper is a contribution of the Long Point Bird Observatory and is Ontario Ministry of Natural Resources, Wildlife Research Contribution No. 83-06.

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Received 3 June 1983
Accepted 4 February 1984

Appendix I. Calculation of estimated total number of breeding pairs of Great Blue Herons in colonies reported to the Ontario Heronry Inventory.

The estimated total number of breeding pairs, T, in Ontario in 1980-81 is given by

$$T = \Sigma E_i$$

where E_i is our best estimate of the number of pairs in colony i in 1980-81 and the sum is taken over all such colonies, i, in Ontario reported to the Ontario Heronry Inventory. (All sums, Σ, in this Appendix are taken over all colonies, i).

We used the following hierarchy of data to derive our best estimate of colony size: (a) results of the 1980 and 1981 breeding season counts, (b) the most recent reliable breeding season estimate of numbers of pairs in 1975-81, (c) the most recent reliable non-breeding season estimate of numbers of nests in 1975-81, (d) the average colony size for the latitude of the colony.

(a) If a breeding season count was done at colony i in 1980-81 then $E_i = A_i$, where A_i is the number of nests reported to be in use plus ½ the number whose status was unknown (DesGranges 1980) in the most recent count in 1980-81. If two counts were done in the most recent year we used the result we judged most reliable (usually the highest count).

(b) If a breeding season count was not done in 1980-81 (i.e. A_i was not available) but there was a breeding season estimate in 1975-79 of the number of pairs in colony i, then $E_i = B_i \times P_j$ in which B_i = the most recent reliable breeding season estimate of the number of pairs in colony i in 1975-81 and P_j is a correction factor applicable to the set of colonies G(j), j = 1,2,3, . . . J, and B_i falls within a certain size range (arbitrarily chosen) which defines the set of colonies G(j). G(1) refers to the colonies with B_i in the lowest size range; G(2) to the colonies with B_i in the next lowest size range; and so on. P_j was determined from:

$$P_j = \frac{\Sigma A_i r_{ij}}{\Sigma B_i r_{ij}}$$

where r_{ij} = 1 if both A_i and B_i are known for colony i and colony i is in set G(j),
0 otherwise.

Note that if colony i was previously active with estimated size B_i and a nest count was done in 1980-81 but gave $A_i = 0$, then $r_{ij} = 1$. Values of P_j from our data are shown in Table 5.

TABLE 5. Values of correction factor P_j (see text, Appendix I).

	Estimated Colony Size (No. breeding pairs)					
	0-15	16-30	31-50	51-100	101-150	151+
P_j	1.24	1.38	1.61	1.19	0.95	0.85

(c) If neither A_i or B_i was available but there was a non-breeding season count of nests in colony i in 1975-81, then $E_i = C_i \times Q_a$, where C_i = the most recent reliable non-breeding season estimate of numbers of nests in colony i in 1975-81 and Q_a is a correction factor applicable to colonies in area a calculated as:

$$Q_a = \frac{\Sigma A_i s_{ia}}{\Sigma C_i s_{ia}}$$

where s_{ia} = 1 if both A_i and C_i are known and colony i is in area a,
0 otherwise.

Note that for a colony in area a, if $C_i > 0$ and $A_i = 0$, then $s_{ia} = 1$. Our data gave values of Q_a as follows: Northern Census Area = 0.949; Eastern Census Area = 0.901; Southern Census Area = 0.965; and all other areas = 0.907.

(d) If none of A_i, B_i or C_i was available for colony i, then, because mean colony size decreases with latitude, we estimate E_i from:

$$E_i = D_k = \frac{\Sigma E'_i t_{ik}}{\Sigma t_{ik}}$$

where E'_i represents a value of E_i previously determined from A_i, B_i or C_i and
t_{ik} = 1 if colony i is at latitude k°N and E'_i is available,
0 otherwise.

Values of D_k derived from our data are shown in Table 6.

TABLE 6. Values of average colony size D_k at different latitudes (see text, Appendix I).

	Latitude (°N)[1]													
	41	42	43	44	45	46	47	48	49	50	51	52	53	54
D_k	137.0	80.2	70.4	41.3	25.0	29.5	12.2	22.5	16.8	25.1	15.7	12.0	13.3	10.0
n	2	8	12	70	61	63	20	50	24	7	14	3	4	1

[1]Latitude 41°N includes all localities from 41°0′N to 41°59′N, etc.

Appendix II. Calculation of estimated total number of active known colonies of Great Blue Herons in Ontario.

The estimated total number of active colonies N in Ontario in 1980-81 is given by:

$$N = V + \sum_{j=1}^{J} U_j \frac{L_j}{M_j}$$

where V is the number of colonies visited in 1980-81 and found to be active; U_j is the number of active colonies last visited in 1975-79 in the set of colonies G(j), j = 1,2,..., J, defined by an arbitrarily chosen range of colony size estimates; M_j is the number of colonies in the set G(j) reported active in 1975-79, whose status was also determined from visits in the 1980-81 breeding seasons; and L_j is the number of those M_j colonies which were active in 1980-81. Values of L_j / M_j, which is the proportion of those colonies reported active in 1975-79 which were still active in 1980-81, for the two size ranges used in this study are as follows: for colonies of 1-15 pairs, 0.677; for larger colonies, 0.957.

Polar Bears, *Ursus maritimus*, as Predators of Belugas, *Delphinapterus leucas*.

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Smith, T. G. 1985. Polar Bears, *Ursus maritimus*, as predators of Belugas, *Delphinapterus leucas*. Canadian Field-Naturalist 99(1): 71-75.

Deux attentats de chasse par des Ours Polaires, *Ursus maritimus*, sur les Marsouins Blancs, *Delphinapterus leucas*, ont été observés. Nos observations du comportement du Marsouin Blanc à Cunningham Inlet, Territoires du Nord-Ouest, indiquent que les Ours Polaires viennent occasionnellement à l'endroit, démontrent un intérêt envers les marsouins et une fois un ours à tenté de les chasser. La fréquence de visite à Cunningham par les Ours Polaires n'augmente pas durant l'occupation de la baie par les marsouins. Les Marsouins Blancs s'échouent occasionnellement dans les eaux peu profondes et ceci pourrait nous faire croire qu'ils sont très vulnérables à la prédation par les ours. Nous avons documentés des cicatrices et plaies probablement causés par des attaques d'Ours Polaires mais cela semble être un petit pourcentage des cicatrices observés. Le petit nombre d'échouage complet que nous avons observé sur trois ans, le comportement prudent et l'extrême sensibilité des Marsouins Blancs envers les bruits causés par les pas d'ours ou d'homme dans le fond de l'eau, indique que les Ours Polaires n'auraient pas souvent de succès à les chasser. Le regime alimentaire des Ours Polaires durant l'été n'est pas bien connue mais il semble que les Marsouins Blancs n'en font pas une partie significative.

Polar Bears, (*Ursus maritimus*), were observed on two occasions attempting to hunt Belugas (*Delphinapterus leucas*), which were occupying shallow water areas. Observations over five years on Beluga Whale behavior, in the Cunningham Inlet area, Northwest Territories, indicate that bears occasionally visit the inlet, show interest in the whales and on one occasion attempted to hunt them. However the frequency of bear visits to the inlet does not appear to increase with the presence of whales. The beaching or stranding behavior of Belugas in river deltas would, at first observation, lead to the assumption that they are extremely vulnerable to Polar Bear predation. While we have observed scars on Belugas which are likely results of bear attacks, they appear to be a small percentage of the total number of wounds observed. The small number of complete strandings observed by us in a three year period, plus the extreme wariness of Belugas and their ability to detect the slightest sound made by an animal or man walking in the shallow water, indicates that bears would not often be successful in hunting them. The summer diet of Polar Bears is poorly documented but it would appear that Belugas do not form a significant part of it.

Key Words: Polar Bears, *Ursus maritimus*, Beluga, *Delphinapterus leucas*, predation, stranding.

The documentation of sources and levels of aquatic predation on marine mammals is extremely difficult because carcasses are not often found and attacks by predators are rarely witnessed. Even when whale or seal carcasses are discovered, along the shore or on the sea ice, they are often in a state of advanced decomposition, or have been fed upon by scavengers, making the certain diagnosis of cause of death virtually impossible.

Belugas (White Whales), *Delphinapterus leucas*, are one of two odontocete whale species adapted to life in arctic waters. Polar Bears, *Ursus maritimus*, have been identified as one of their chief predators along with the Killer Whale, *Orcinus orca*, which is perhaps their principal aquatic enemy. Only a few accounts exist in the literature documenting the actual attack by a Polar Bear on free ranging Beluga Whales. These occurred in situations where Belugas had become confined to a small hole in the ice, termed a *savsatt* by the Inuit of Greenland (Kleinenberg, Yablokov, Bel'kovich and Tarasevich 1964; Freeman 1973). Other accounts implicating Polar Bears as predators of Belugas are based on observation of scars left on whale carcasses (Heyland and Hay 1976) or the observation of a bear feeding on a Beluga carcass (J. Bunch, personal communication, cited in Mitchell and Reeves 1981). One account of the attack and the dragging away of captive Belugas from a holding tank at Churchill, Manitoba (Amherst News, Nova Scotia, cited in Heyland and Hay 1976), clearly shows that Polar Bears consider them as desirable prey.

This paper describes observations made since 1974 of Polar Bears near concentrations of Belugas and of two occasions when actual attacks were witnessed.

Materials and Methods

Most of these observations were made at Cunningham Inlet, (74°05'N, 93°45'W), on the northern coast of Somerset Island, Northwest Territories. Behavioral studies on Belugas which aggregate there from July until mid-August, were conducted in 1974, 1977, and during 1980-82. In the last two years systematic observations using binoculars and spotting telescopes (20–45X) were made, covering the four hours centered on high tides and every two hours from 0900 to 2100 hrs. High tide observations were made from a 6 m high tower erected beside two of the river channels in the delta, which were occupied by Belugas on

the rising tides. The seven daily observations of the whole inlet were made from a hut situated at the southwest corner of the inlet on a 30 m high hill. Systematic observations were made during the periods 16 July to 13 August 1980, 13 June to 16 August 1981, and 16 June to 16 August 1982.

During the sessions from both observation points we made detailed notes on the distribution and activities of the whales in the inlet. Line drawings and photographs of scars and other markings which could serve to identify individual whales were made whenever possible. Scars were subjectively classified as bullet wounds, Polar Bear wounds or unknown. Other sightings of Polar Bears and Belugas were made from aircraft doing surveys for Belugas in the Barrow Strait, Prince Regent Inlet, Peel Sound and Lancaster Sound regions.

Results

Observations of Polar Bears near Beluga concentrations were made primarily in the ice free months of July and August when the whales concentrate in large numbers at Cunningham Inlet (Hay and McClung 1974; Heyland 1974, 1977) and Creswell Bay (K. Finley. 1976. Studies of the status of marked mammals in the central district of Franklin, N.W.T. June-August 1975. Unpublished report by L.G.L. Ltd. for Polar Gas Project, Toronto. 183 pp.). At Cunningham Inlet where systematic observations were made for three years, Polar Bears have been sighted on 17.7% (6/34), 10.7% (3/28) and 3.2% (1/31) days when Belugas were present. In both 1981 and 1982 bears were sighted on 12.5% (3/24) and 8.3% (2/24) of the days prior to whales arriving in the inlet. Although there was a slightly higher number of bears sighted in the inlet when Belugas were present this was not significant when tested using a 2×2 contingency table $\chi^2 = 0.13$, $p > 0.05$).

One aspect of the behavior of Belugas in river deltas might make them especially vulnerable to predation by Polar Bears. Belugas at Cunningham Inlet, and in other high arctic estuaries such as the Fellfoot River and in Creswell Bay move into extremely shallow water. At Cunningham Inlet we observed this to be a regular part of their behavior. On the rising tide whales penetrate into the river channels with the highest outflow. They remain there for several hours, often moving into very shallow areas and exposing a considerable proportion of their body surface to the air, often while remaining immobile and resting on the gravel bottoms. This behavior can lead to partial stranding, but the animal is finally able to get back to deeper water by making violent efforts before low water leaves it entrapped. Complete stranding also occurs and could perhaps result in death, but, at least in two cases which we observed, the animals were able to get off on the next rising tide. In 1980 we observed only two partial strandings; in 1981 nothing even resembling a stranding occurred while in 1982 six partially stranded Belugas and one completely stranded adult female were observed. In the latter instance an adult female stranded in shallow water at 1430 hrs on an ebbing tide, remained in 15 cm of water during the low tide and was gone by 2300 hrs on the next high tide. This animal was not able to swim for approximately nine hours. It was approached, examined by us and appeared to remain in good condition throughout the stranding. Strandings were also documented at Cunningham Inlet prior to the beginning of our systematic behavior studies. Heyland and Hay (1976) documented the stranding of a sexually immature female. This animal was noticed stranded at 0725 hrs on 26 July 1974 and killed by the researchers at 0600 hrs on 27 July 1974. Healed scars on its body indicated to them that it had been attacked by a Polar Bear sometime before it was stranded. In 1977 two strandings were again observed at Cunningham Inlet. On 18 July four Belugas (three adults and one immature calf) were noticed stranded. These were approached and streamer tags attached to them. All were able to return to deep water on the rising tide. Again on the same day an adult male was found beached at 1930 hrs. In none of these cases, when whales were beached, were there any Polar Bears present in the area.

I have kept records of heavily or distinctly scarred Belugas seen at Cunningham Inlet from 1980–82. Most of these have been sighted from our observation tower where the whales are not more than 100 m away. All age groups of Belugas are heavily marked with various types of scars and variations in pigmentation. Since our goal was to use scars and marks for resighting purposes, we have systematic records of only the most distinctive scars. These do not include the frequently seen shallow parallel (usually 3–6) scratches thought to be inflicted by conspecifics, or scratches probably resulting from rubbing on the sharp limestone substrate. Our data are not a reflection of the incidence of the three categories we have subjectively defined, which are bullet wounds, Polar Bear wounds and wounds of unknown origin. Instead the data reflect our preference in using such marks because of their uniqueness and ease of recognition.

Of the scars used in our identification fiches 20.8% (5/24), 16.7% (4/24) and 0% were classified as resulting from Polar Bears in 1980, 1981 and 1982 respectively. The 1982 sample was too small (five identified whales) to reflect the number of bear wounds used by us as visual marks.

Lone Polar Bears were seen hunting Belugas in the

shallow water on two separate occasions. The first incident was witnessed from an aircraft during the last week of July 1981. While passing over the small river entering the ocean at Fellfoot Point, Steve Krasseman (personal communication) observed a Polar Bear in one of the river channels. It was apparently chasing three large Belugas which were situated in the shallow water upstream from it. The outcome of this event was not observed, but survey flights made over the area on 2-4 August did not reveal any Beluga carcasses in the area and none were seen in June 1982 when we returned and carefully examined the site.

During our Beluga observations from the tower in Cunningham Inlet I witnessed a lengthy stalk of Belugas by a large presumed male Polar Bear on 21 July 1982. Observation from the tower lasted from 1100 to 1535 during that session. The bear was first seen at 1105 standing motionless on the land approximately 2 m from the side of a channel in the east part of the delta, which was densely occupied by some 100–200 Beluga Whales. The channel, which had a wide mouth emptying into the inlet, was 30–40 m across and 2–3 m deep. Our observation tower was approximately 350–400 m west of the bear. Shortly after I sighted the bear it slowly entered the water. Immediately the Belugas swam out of the channel and moved 100 m offshore. The major concentration of Belugas shifted west towards our observation point. After moving a few meters from shore, the bear became immobile. It remained so for approximately one minute, then swam slowly north towards the whales until it was approximately 100 m from its point of entry and 60 m from the nearest Beluga. At this point the bear stopped and raised itself out of the water on its hind legs, apparently standing on the bottom. It looked around and sniffed the air for a few minutes in this manner. It then began slowly swimming north towards the whales which occasionally appeared to come within 6–10 m of it, but generally maintained a distance of 60–80 m. At 1128 some whales began returning to the channel, which had been vacated previously. At this point the bear had approached the offshore whales and dove on four separate occasions when whales came near it, in apparent attempts to catch them. After the second lunge, the nearshore whales, which had again occupied the channel, rapidly moved offshore and away from the bear. The whales appeared to maintain a good distance from the Polar Bear after the attempted kills. The bear slowly swam north towards some floating ice and was lost to sight by 1145 because of heavy fog.

A definite shift in the distribution of whales was seen as a result of the attempted predation by the bear, but no short or long term change was noticed in the number of whales occupying the inlet. This was also true on the four other occasions on which Polar Bears were seen to enter the water when Belugas were present in Cunningham Inlet. In none of these cases, however, were the bears observed to actually attempt to hunt whales.

There is no doubt that Polar Bears will attempt to kill prey as large as a Beluga or Narwhal. Some evidence exists that bears will tend not to attack large Walruses, *Odobenus rosmarus,* which they apparently learn to recognize as potentially dangerous adversaries (Popov 1958; Fay 1982). The role of the Polar Bear as an aquatic predator remains poorly described. Bears are sometimes sighted considerable distances from land in the summer ice-free season (Degerbol and Freuchen 1935). Some evidence exists that they are able to hunt seals in the open water (Furnell and Oolooyuk 1980) and the present observations indicate that this might also hold for the hunting of Belugas. Polar Bears appear to be true marine mammals in their hunting habits, to the extent that they will stalk seals by swimming towards them under a solid ice cover (Stirling 1974; Smith 1980).

The documentation of levels of predation on marine mammals by Polar Bears will remain a difficult task. Interpretations of predation rates based on evidence of scars are extremely tenuous because of the difficulty in obtaining unbiased and accurate information. The origin of scars on Belugas, which have extremely fragile skin during the summer months, could particularly be subject to misinterpretation. Based on my experience, I believe that Heyland and Hay (1976) were mistaken in thinking that the scars seen on the stranded Beluga calf illustrated in their paper came from a Polar Bear. These appeared to be inflicted by conspecifics, a frequently observed type of scar and one also noted by Brodie (1967).

Polar Bears could kill Belugas in several different types of hunting situations. Hunting at small openings in the ice (*savsatts*), where Beluga or Narwhal have become entrapped, might be one of the most productive situations. In fact, the only definite cases of bears killing Belugas occurred in this manner (Kleinenberg et al. 1964; Freeman 1973). It should be noted however that several detailed descriptions of Beluga and Narwhal entrapments completely omit any mention of Polar Bear predation (Porsild 1918; Vibe 1950; Freeman 1968). Naturally occurring polynyas of various sizes are widespread throughout the Canadian arctic, and Polar Bears are often found associated with them. Belugas which winter mostly along the edge of the pack ice are not often found in such areas. Bears hunting in polynyas are either preying on Ringed Seals, *Phoca hispida,* or making use of some other resource, such as kelp (Stirling, Cleator and Smith 1981). It appears therefore that Beluga hunting

by bears at *savsatts* or polynyas is opportunistic and probably does not frequently occur.

Little is known of the success or methods used by Polar Bears hunting along the floe edge or along the side of leads. I have often seen bears lying still, with their head just at the edge of the floe, apparently waiting for either a seal or whale to surface and have also seen bears in the water swimming slowly along the ice edge. Ice edges are areas rich in many forms of mammal and bird life in the springtime and Belugas are often seen swimming and feeding in these areas. Bears usually drag their kills onto the ice to feed and since few carcasses of Belugas have been found on the ice it would appear that successful predation in this situation, where Belugas could dive to escape, is extremely rare.

Narwhals which occupy narrow leads and ice edges, in areas where bears concentrate, might give some indication of bear predation in this situation. In two studies which examined scars on this species (Silverman 1979; Finley and Miller 1982), no mention is made of any wounds which might be attributed to Polar Bear attacks. This might have been overlooked because of the authors' interest in conspecific and hunting related wounds.

The vulnerability of Belugas to predation during their occupation of shallow water areas in the summer time would appear at first glance to be quite high. The beaching behavior of Belugas could, in the extreme cases I have documented, lead to a successful kill if a bear was present. This situation occurs rarely however, and our observations of the number of bears visiting Cunningham Inlet during the period of whale occupation are very few. The extreme wariness of Belugas (Degerbol and Freuchen 1935) and their observed alertness to any sound, such as the slight movement of gravel, probably serves well to protect them from approaches from the land.

It appears that Polar Bears only opportunistically hunt Belugas and it is likely that their success is minimal. While Ringed Seals in the ice covered period are their chief prey species (Stirling and McEwan 1975; Smith 1980) their summer food habits in a large part of their range remain poorly known.

Acknowledgments

I thank Gary Sleno, Wybrand Hoek and David Sergeant of the Arctic Biological Station for use of unpublished observations and Dr. A. W. Mansfield for constructive criticism of the manuscript. Dan Gauthier, Walter Klenner, Becky Sjare, Mike Wyszkowski, summer students, and Doug Hope, of the Arctic Biological Station, made some of the observations. Dr. Ian Stirling, Canadian Wildlife Service, made useful suggestions about the manuscript. I am grateful for the considerable financial and logistic support of the Polar Continental Shelf Project, Department of Energy, Mines and Resources, and I particularly thank George Hobson, Fred Alt, Barry Hough and Frank Hunt for their cheerful and dependable assistance in the field.

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Received 10 June 1983
Accepted 13 December 1983

The Ecology of Freshwater Gastropods on the Southwestern Edge of the Precambrian Shield

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Pip, Eva. 1985. The ecology of freshwater gastropods on the southwestern edge of the Precambrian Shield. Canadian Field-Naturalist 99(1): 76–85.

The ecology of freshwater gastropods was examined in relation to community diversity and surface water pH, total alkalinity, total dissolved solids, total nitrate and nitrite, phosphate, chloride, sulphate and dissolved organic matter at 100 sites on the southwestern edge of the Precambrian Shield. Of the 31 gastropod species found in the area, 15 were recorded at 5 or more sites, and of these, *Gyraulus deflectus* occurred in the most diverse snail and aquatic plant communities; *Stagnicola elodes* frequented communities with low diversity. *Helisoma campanulatum* showed the greatest tendency to occur in waters with low total dissolved solids, while *S. elodes* appeared to be poorly adapted to the soft waters of the region. Chi-square analysis of interspecific gastropod associations adjusted for apparent tolerance ranges yielded a single planar cluster composed of 13 species interrelated by 18 positive associations. Chi-square tests also identified 49 positive snail-plant associations, 11 of which involved *H. campanulatum*.

Key Words: freshwater gastropods, diversity, water chemistry, tolerance range, interspecific associations, Precambrian Shield.

Gastropod molluscs are an important component of submerged aquatic communities. The occurrence of freshwater gastropods in relation to water chemistry has been studied by a number of workers (e.g. Boycott 1936; Frömming 1938; Macan 1957; Aho 1966, 1978b; Dussart 1976; Ökland 1979; Pip 1978; Ökland and Ökland 1980; Aho et al. 1981), who suggested that factors such as calcium hardness, total alkalinity and pH are significant in determining mollusc distribution. The species richness of gastropod communities tends to decrease at lower values of these parameters, with very limited numbers of species occurring towards the lower end of the scale (Aho, 1966, Ökland and Ökland, 1980), while many species may also show decreased population densities in such waters (McKillop and Harrison 1972).

The Canadian Shield region is of particular interest with respect to mollusc ecology because of the abundance of oligotrophic and dystrophic habitats it provides. Values for dissolved inorganics in waters of this area not uncommonly fall below the levels considered to be limiting for gastropods in Scandinavian waters, where the problem has been relatively well studied (e.g. Ökland and Ökland 1980). Little is known regarding the ecology of freshwater molluscs in North American oligotrophic waters.

The present study was undertaken in an attempt to examine the apparent tolerance ranges of gastropods with respect to pH, total alkalinity, total dissolved solids, total nitrate and nitrite, molybdenum reactive phosphorus, chloride, sulphate and dissolved organic matter at 100 stations on the southwestern edge of the Precambrian Shield. Snail and aquatic plant community diversity, and interspecific associations among gastropods as well as among plants and gastropods were also examined.

Study Area

A total of 100 established permanent aquatic habitats were surveyed within 49°37′ – 51°10′ N and 95°00′ – 96°20′ W (Figure 1). All of the stations were underlain by granitic bedrock: 41% had bedrock bottoms with thin pockets of sediment and organic debris, 9% had gravel overlying rock, 33% had sand, 7% had clay and 10% had primarily organic substrates. A total of 40% of the sites were lakes (> 10 ha), 24% ponds (< 10 ha), 24% rivers (> 2 m deep) and 12% creeks (< 2 m deep).

Methods

The survey was conducted during the May to September 1978 season. The snails and macrophytes were examined at each site by wading or canoeing within a search time of 1 h. Within this time smaller sites could be explored completely. Large water bodies were sampled at a number of stations and each was treated as a separate site because of possible internal environmental variation (e.g. Jensen 1979). Macrophytes and snails were obtained from deeper waters with a rake. Only macrophytes that were at least partially submerged were considered.

A surface water sample was collected at each site, immediately placed in ice in a lightproof container and frozen within 12 h. Surface pH was measured *in situ* with a portable Radiometer (Copenhagen) pH-meter. Water samples were analyzed according to

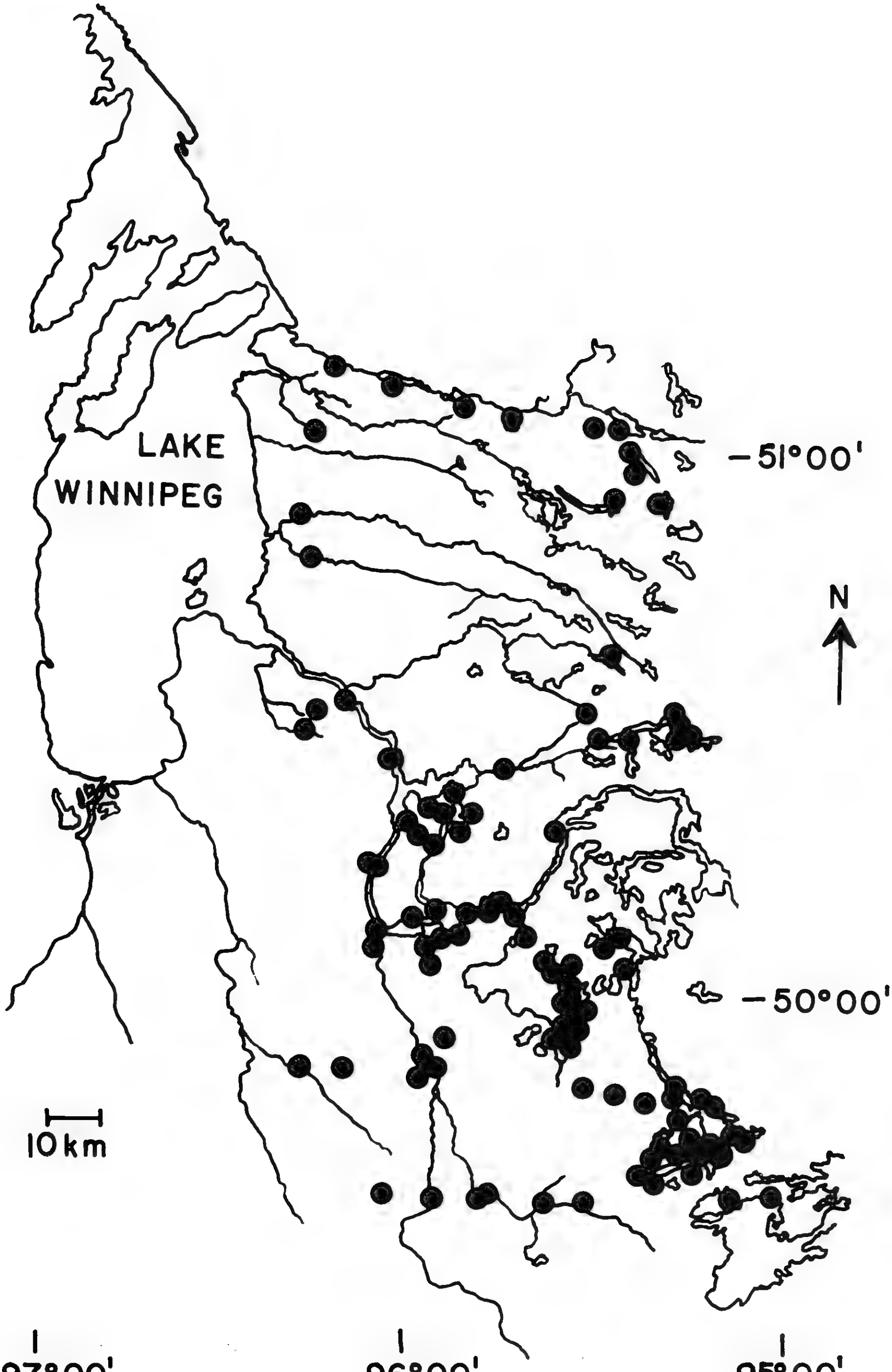

FIGURE 1. Location of study sites.

TABLE 1. Percent frequency and distribution with respect to water body type for gastropods within the study area, and snail and plant diversity at sites where each gastropod was recorded. Distribution values are percentages of the total occurrences of each species. Snails recorded at fewer than five sites have been excluded.

	Water body type						
Gastropod	% frequency	Lakes > 10 ha	Ponds < 10 ha	Rivers > 2 m deep	Creeks < 2 m deep	Snail diversity	Plant diversity
Physa gyrina (Tadpole Snail)	53	41.5	24.5	28.3	5.7	4.1	9.3
Lymnaea stagnalis (Great Pond Snail)	33	39.4	36.4	24.2	0	4.6	9.7
Helisoma trivolvis (Larger Eastern Ramshorn)	29	34.5	24.1	27.6	13.8	4.2	11.4
Gyraulus parvus (Modest Gyraulus)	27	40.7	22.2	33.4	3.7	4.7	10.7
Helisoma campanulatum (Bell-mouthed Ramshorn)	24	62.5	0	37.5	0	4.9	12.1
Amnicola limosa (Ordinary Spire Snail)	21	47.6	4.8	47.6	0	5.1	11.1
Ferrissia rivularis (Sturdy River Limpet)	19	47.4	10.5	26.3	15.8	3.1	9.4
Helisoma anceps (Two-ridged Ramshorn)	16	43.8	37.5	12.4	6.3	4.2	7.7
Bulimnea megasoma (Showy Pond Snail)	11	36.4	9.1	54.5	0	6.1	11.4
Gyraulus deflectus (Irregular Gyraulus)	9	55.6	0	44.4	0	6.6	13.8
Promenetus exacuous (Keeled Promenetus)	9	55.6	0	44.4	0	6.4	11.3
Stagnicola elodes (Common Stagnicola)	8	0	75.0	12.5	12.5	3.9	5.0
Helisoma pilsbryi (Greater Carinate Ramshorn)	7	28.6	28.6	42.8	0	5.0	9.9
Planorbula armigera (Say's Toothed Planorbid)	7	14.3	14.3	57.1	14.3	6.0	12.9
Cincinnatia cincinnatiensis (Campeloma Spire Snail)	5	60.0	20.0	20.0	0	5.2	12.0
Total sites sampled	100	40	24	24	12	3.0	9.1

methods recommended by the American Public Health Association (1971), as described in Pip (1977).

Results

A total of 31 gastropod species was found in the study area, of which 15 were recorded at five or more sites (Table 1). *Physa gyrina* (Tadpole Snail) was the most frequently encountered snail in the area, followed by *Lymnaea stagnalis* (Great Pond Snail). The following species were recorded at fewer than five sites: *Valvata tricarinata* (Three-keeled Valve Snail), *Campeloma decisum* (Brown Mystery Snail), *Amnicola walkeri* (Small Spire Snail), *Probythinella lacustris* (Flat-ended Spire Snail), *Stagnicola caperata* (Blade-ridged Stagnicola), *S. reflexa* (Striped Stagnicola), *Fossaria decampi* (Shouldered Northern Fossaria), *F. exigua* (Graceful Fossaria), *F. modicella* (Modest Fossaria), *F. parva* (Amphibious Fossaria), *Aplexa hypnorum* (Polished Tadpole Snail), *Ferrissia parallela* (Flat-sided Lake Limpet), *Helisoma corpulentum* (Capacious Manitoba Ramshorn), *Armiger crista* (Tiny Nautilus Snail), *Promenetus umbilicatellus* (Umbilicate Promenetus) and *Gyraulus circumstriatus* (Flatly Coiled Gyraulus). Nomenclature is from Clarke (1981).

Distribution data for the more common taxa with respect to water body type (Table 1) suggested that many species frequented certain water body types when compared to the overall sampling distribution. *Helisoma campanulatum* and *Cincinnatia cincinnatiensis* tended to occur in lakes, while *Planorbula armigera* and *Bulimnea megasoma* were most often found in rivers. *Stagnicola elodes* showed a strong preference for ponds.

TABLE 2. Water chemistry parameter values for species with significant ($p < 0.05$) affinities within the sampled range.

Parameter	Species	Mean	$S.E._{\bar{X}}$	Maximum	Minimum
pH	*Lymnaea stagnalis*	7.8	0.1	9.5	6.5
	Stagnicola elodes	8.5	0.3	9.5	6.7
	Total sites sampled	7.5	0.1	9.5	5.0
Total dissolved solids, mg/L	*Stagnicola elodes*	184	32	365	68
	Helisoma campanulatum	75	7	219	30
	Total sites sampled	101	7	369	10
Total alkalinity, mg/L $CaCO_3$	*Stagnicola elodes*	165	33	316	36
	Total sites sampled	60	7	316	0
Chloride, mg/L	*Helisoma anceps*	3.3	1.7	22	0
	Total sites sampled	1.1	0.4	26	0
Total nitrate and nitrite, mg/L	*Lymnaea stagnalis*	0.77	0.15	2.83	0
	Stagnicola elodes	1.53	0.32	2.83	0
	Total sites sampled	0.54	0.08	3.68	0

Diversity of snail communities, gauged by the total number of species recorded at each site (Table 1), indicated that, on average, *Gyraulus deflectus*, *Promenetus exacuous*, *Bulimnea megasoma* and *Planorbula armigera* occurred in the most diverse communities, while *Ferrissia rivularis* and *Stagnicola elodes* frequented those with the least diversity. Overall diversity for the sites sampled was only 3.0 because of the inclusion of 10 sites where no snails were recorded. Maximum recorded diversity was 13. Of the rarer species, *Valvata tricarinata* was found only at the sites with the highest diversity. *Stagnicola caperata* and *Fossaria modicella* were each the only species observed at their respective sites.

Diversity of macrophyte communities at the sites where each snail was recorded (Table 1) showed that *Gyraulus deflectus* and *Planorbula armigera* occurred in the most speciose communities, while *Stagnicola elodes* and *Helisoma anceps* were found in the least diverse sites. Macrophyte diversity of the sites sampled ranged from 1 to 25. Beyond the tendency for ponds to be poor in both snail and plant diversity, no significant correlation was seen between the two types of diversity at other sites.

Gastropods that were present at fewer than five sites were excluded from all subsequent analysis. Unpaired t-tests were conducted to compare the means for water chemistry parameters at sites where each species was present and where it appeared to be absent, where sampling distributions of the groups being compared were similar. Although the total ranges sampled for water chemistry were relatively narrow because of the similarity of waters in the area, four species nonetheless showed significant preferences for higher or lower values within the ranges of some of the parameters examined (Table 2). Most of the affinities that emerged were for higher parameter values, except for *Helisoma campanulatum*, which tended to occur at significantly lower values. *Stagnicola elodes* showed strong positive affinities for four parameters. None of the species examined showed significant tests for molybdenum reactive phosphate (sampling range (0-7.3 mg/l) or sulphate (sampling range 0-41 mg/l).

The significance of the tendency for pairs of different gastropods to occur at the same site was tested by applying a Chi-square test with Yates' correction factor (Cole, 1949) to the presence-absence data. Because the taxa in Table 2 occurred only within a restricted range for some of the water chemistry parameters, these species would not be expected to occur at equal probabilities throughout the total sampling range. Accordingly for each species pair tested in which one or both members were restricted in their occurrence, all sites whose values fell outside the apparent tolerance ranges of the appropriate parameters in Table 2 were excluded from the contingency table. Each pair was limited by the member and parameter with the most restricted range.

The results showed a total of 18 significant ($p < .05$) positive associations among 13 of the 15 major species occurring in the area. The two species which showed no positive associations were *Stagnicola elodes* and *Ferrissia rivularis*; these tended to frequent the least diverse gastropod communities. *Stagnicola elodes* was also restricted to sites (mainly ponds) with parameter values at the upper end of the sampled scale.

The gastropod associations assumed the configuration in Figure 2, where distances between species represent the reciprocals of Chi-square values, adjusted for apparent tolerance ranges. All of the associations could be fitted in two dimensions, except that between *Helisoma pilsbryi* (8) and *Planorbula armigera* (10), where the distance between the species was greater than that possible in the given configuration. This may have been due to distortion arising

TABLE 3. Significant ($p < 0.05$) positive and negative snail-plant associations ranked according to Chi-square values.

Positive associations

Snail	Plant	χ^2	% of sites where snail present
Amnicola limosa	*Ranunculus aquatilis* (White Water Buttercup)	10.8	33
	Elodea canadensis (Common Elodea)	10.5	57
	Vallisneria americana (Wild Celery)	5.5	57
	Zosterella dubia (Water Stargrass)	3.9	24
Lymnaea stagnalis	*Chara* spp. (Muskgrass)	12.5	30
	Eleocharis spp. (Spikerush)	7.1	64
	Potamogeton gramineus (Variable Pondweed)	4.8	36
Bulimnea megasoma	*Polygonum amphibium* (Water Smartweed)	11.0	64
	Spirodela polyrhiza (Big Duckweed)	8.2	64
	Zizania aquatica (Wild Rice)	7.9	36
	Sium suave (Water Parsnip)	6.7	55
	Potamogeton obtusifolius (Bluntleaf Pondweed)	4.7	27
	Utricularia vulgaris (Common Bladderwort)	4.4	55
Stagnicola palustris	*Chara* spp. (Muskgrass)	37.4	75
	Potamogeton pectinatus (Sago Pondweed)	16.5	25
Helisoma anceps	*Potamogeton gramineus* (Variable Pondweed)	4.1	44
H. campanulatum	*Potamogeton richardsonii* (Richardson's Pondweed)	29.1	83
	Elodea canadensis (Common Elodea)	23.9	67
	Ranunculus aquatilis (White Water Buttercup)	23.7	38
	Zosterella dubia (Water Stargrass)	12.6	29
	Vallisneria americana (Wild Celery)	11.0	63
	Megalodonta beckii (Water Marigold)	10.7	42
	Myriophyllum exalbescens (Northern Watermilfoil)	10.5	58
	Ceratophyllum demersum (Coontail)	9.1	63
	Lemna trisulca (Star Pondweed)	8.4	29
	Potamogeton zosteriformis (Flatstem Pondweed)	7.0	42
	Zizania aquatica (Wild Rice)	4.4	25

(continued)

TABLE 3. *(concluded)*

Snail	Plant	χ^2	% of sites where snail present
Positive associations			
H. trivolvis	*Spirodela polyrhiza* (Big Duckweed)	18.2	55
	Sium suave (Water Parsnip)	16.9	48
	Sagittaria spp. (Arrowhead)	7.3	55
	Callitriche spp. (Water Starwort)	6.5	28
	Mentha arvensis (Water Mint)	6.0	35
	Lemna minor (Little Duckweed)	5.6	52
	Potamogeton obtusifolius (Bluntleaf Pondweed)	4.6	17
Planorbula armigera	*Spirodela polyrhiza* (Big Duckweed)	13.3	86
	Sium suave (Water Parsnip)	9.6	71
	Polygonum amphibium (Water Smartweed)	8.8	71
	Alisma triviale (Broadleaf Water Plantain)	8.6	71
	Sagitteria spp. (Arrowhead)	7.1	86
	Utricularia vulgaris (Common Bladderwort)	7.0	71
Promenetus exacuous	*Elodea canadensis* (Common Elodea)	6.0	67
Gyraulus parvus	*Potamogeton foliosus* (Leafy Pondweed)	8.0	31
	P. zosteriformis (Flatstem Pondweed)	4.8	38
G. deflectus	*Nuphar variegatum* (Spatterdock)	12.5	67
	Potamogeton amplifolius (Bigleaf Pondweed)	12.5	56
	Zizania aquatica (Wild Rice)	11.6	44
	Megalodonta beckii (Water Marigold)	6.2	56
	Potamogeton richardsonii (Richardson's Pondweed)	5.3	78
	Myriophyllum exalbescens (Northern Watermilfoil)	3.9	67
Negative associations			
Amnicola limosa	*Utricularia intermedia* (Flatleaf Bladderwort)	-4.2	
Physa gyrina	*Utricularia intermedia* (Flatleaf Bladderwort)	-8.5	
Helisoma anceps	*Elodea canadensis* (Common Elodea)	-4.3	

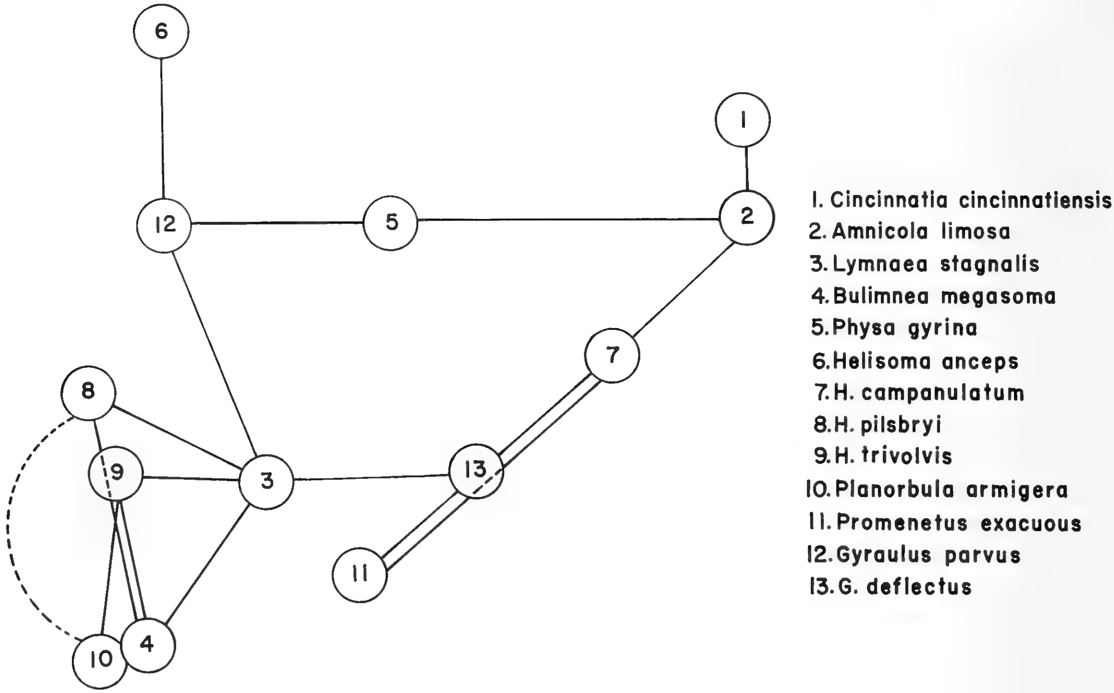

FIGURE 2. Significant positive associations between gastropods in the study area. Distances represent χ^{-2} units.

from the small number of occurrences of both species (7), or to restrictions operating with respect to other, unmonitored, parameters. The greatest number of associations, a total of five, was shown by *Lymnaea stagnalis* (3), which thus appears to occupy a central position in the cluster. The most closely associated species were *Bulimnea megasoma* (4) and *Planorbula armigera* (10).

The linear relationship between *Helisoma campanulatum* (7), *Gyraulus deflectus* (13), *Promenetus exacuous* (11) and, to a lesser extent, *Amnicola limosa* (2), may reflect the strong tendencies of these species to occur in lakes and rivers, where seasonal variation is less pronounced.

Chi-square tests were also used to identify snail-macrophyte associations. Values were again adjusted for apparent tolerance ranges of both snails and plants. The results showed a total of 49 significant positive and 3 negative associations (Table 3). *Helisoma campanulatum* showed the greatest number (11) of positive associations, followed by *Bulimnea megasoma*, *Planorbula armigera* and *Gyraulus deflectus*, with 6 associations each. The plants most frequently associated with gastropods in the region were *Elodea canadensis* (Common Elodea), *Spirodela polyrhiza* (Big Duckweed), *Zizania aquatica* (Wild Rice) and *Sium suave* (Water Parsnip).

Discussion

The southwestern edge of the Precambrian Shield region is the most diverse area of central Canada in terms of both gastropods and macrophytes (Pip 1978). This region has thus far escaped much of the effects of acid rain which have ravaged such sites farther east: for example, sulphate levels are generally below measurable levels except at developed sites or where drainage from roadways is present. Half of the 31 gastropod species of the area are limited to one or a few sites, some of which are at present endangered by encroaching development. In recent times the area has had even greater gastropod diversity than at present. *Pseudosuccinea columella* (American Ear Snail), recorded at many localities in the area during the first part of the century, has not been seen for more than four decades, presumably as a result of intensive recreational use and subsequent deterioration in quality of the sites where it occurred (Pip 1979). The greater diversity of unencroached Shield habitats may be a reflection of their stability, since fluctuating environments are often characterized by less diversity (Emlen 1977).

Because of their isolation, aquatic habitats may be considered analogous to islands with respect to colonization processes and maintenance of diversity (e.g. Lassen 1975; Aho 1978a and b). Diversity at a given

aquatic site is not only a product of the opportunity that has been available for colonizers to arrive, but also reflects the ability of the species present to survive and adapt to the existing conditions and to each other. At permanently established, unperturbed sites a dynamic equilibrium is eventually reached between extinction of existing species and immigration of new ones (MacArthur and Wilson 1963). Overall diversity in an undisturbed isolated habitat tends to fluctuate very little over time (Simberloff and Wilson 1969).

Lassen (1975) found that, for Danish waters within a given nutrient class, diversity of snail communities can be correlated with water body surface area, this apparently being a reflection of the number of waterfowl visits to the sites, since aquatic birds are the primary dispersal agents for freshwater snails (e.g. Castell 1962). In the present study, ponds showed the lowest snail and plant diversity. However, these sites also often showed the most extreme water chemistry values.

Because the total sampling range for water chemistry parameters in Shield sites was much narrower than the range encountered in waters to the west of the Shield edge (Pip 1984), only four gastropods showed any partitioning within the narrower range. In a wider range of habitats previously examined in central Canada (Pip 1978), *Amnicola limosa*, *Bulimnea megasoma*, *Physa gyrina*, *Ferrissia rivularis*, *Helisoma campanulatum*, *H. anceps*, *Planorbula armigera* and *Gyraulus deflectus* showed affinities for lower values of at least some parameters, but, with the exception of *H. campanulatum*, these affinities disappeared in the narrower range sampled in the present study. *Helisoma campanulatum* may thus be regarded as the most specialized for oligotrophic Shield waters, because it continued to show preferences for lower values of total dissolved solids and dissolved organic matter within the ranges available in the Shield region. The intolerance by this species of higher parameter values and of seasonal fluctuations was also reflected in its avoidance of ponds and creeks.

In central Canada, *Lymnaea stagnalis*, *Stagnicola elodes*, *Helisoma trivolvis* and *Promenetus exacuous* show some preferences for higher parameter values (Pip 1978), but these preferences were often not significant when only Shield waters were considered. For *Lymnaea stagnalis*, previously seen affinities in central Canada for higher values of dissolved organic matter and phosphate disappeared in Shield waters, while affinities for higher values of pH and total nitrate and nitrite appeared. *Stagnicola elodes* retained its affinities for higher values of pH, total dissolved solids, total alkalinity and total nitrate and nitrite, but relinquished its affinities for higher values of chloride, sulphate and phosphate. The negative affinity of *Helisoma anceps* for total dissolved solids in central Canada disappeared with the lower sampling range, but an affinity for higher chloride levels appeared in the Shield region, where chloride levels are generally below measurable levels.

The absence in Shield waters of many affinities for higher values seen in the broader distributional ranges of the gastropods is interesting in that it suggests that regional adaptation has occurred to the lower parameter values that predominate in the Shield region. Similar regional discrepancies have been observed for macrophytes occurring in Shield waters (Pip 1984). For snails such discrepancies were particularly evident for phosphate: *Amnicola limosa*, *Lymnaea stagnalis*, *Stagnicola elodes*, *Physa gyrina*, *Helisoma trivolvis*, *Planorbula armigera* and *Promenetus exacuous* were more frequently found at higher values of this parameter where such values were available in central Canada, but this factor was not significant within the narrow range of lower values seen in the Shield waters. Of the more common species examined, *Stagnicola elodes* apparently adapts the least to habitats with low values of dissolved inorganics and this snail is likely under stress in the Shield region, where it is pushed to the lower limits of its tolerance range. Thus it cannot compete well with species that are more specialized for habitats where dissolved materials are low and this may explain why it is found primarily in ponds, even though many of these habitats have been in existence for comparatively short periods of time. Inability to adapt to low parameter values may be responsible for the rarity in Shield waters of species such as *Armiger crista* and *Fossaria modicella*, which frequent waters with high values of dissolved inorganics (Pip 1978). This may also be why *Physa jennessi*, a very common species of alkaline waters west of the Shield, has failed to become established in Shield habitats.

Lymnaea stagnalis may be regarded as a marginally stressed species in the Shield region because its limitations with respect to pH and total nitrate and nitrite become apparent only in a sampling range concentrated at the lower end of the scale.

In a survey of 1500 sites in Norway, Ökland and Ökland (1980) found that most gastropods do not occur below pH 6.0, with only a few species being able to tolerate values as low as 5.2. In the present study most of the gastropods found in the Shield area could occur down to summer values of pH 6.0, but *Helisoma trivolvis* was observed at pH values as low as 5.0. A relationship appeared to exist between pH and snail community diversity that was similar to the correlation reported by Aho (1966) for habitats in southern Finland.

The interspecific associations detected in this study

are also known in areas outside the Precambrian Shield (Pip 1978), except for the association between *Lymnaea stagnalis* and *Bulimnea megasoma*, and the associations of *Helisoma pilsbryi*. The latter gastropod is much more common in the Shield area and thus associations with this species are more apparent. The absence of associations with *Stagnicola elodes* is significant in view of the different ecology of this snail. The absence of associations with *Ferrissia rivularis* is harder to explain. This species apparently has a completely random distribution within the study area.

Although *Lymnaea stagnalis* appeared to be marginally stressed in terms of water chemistry, it was associated with the greatest number of species, suggesting that it is versatile with respect to the communities where it can occur.

The importance of aquatic vegetation for freshwater gastropods has been pointed out by a number of workers (e.g. Aho 1966; Ökland 1979; Pip 1978). Many of the snail-plant associations that emerged in the present study are also known for non-Shield areas (Pip 1978). The macrophytes with which snails other than *Stagnicola elodes* was associated themselves form a characteristic association cluster which reflects regional environmental variables (Pip 1983). The macrophytes with which *S. elodes* was associated, i.e. *Chara* spp. and *Potamogeton pectinatus*, are typical of waters with high dissolved inorganics. These associations therefore reflect similar ecological requirements. In the Shield area these species indicate habitats with elevated alkalinity values.

It is important to keep in mind that associations derived from presence-absence data provide only partial information, since a number of subcommunities may coexist within a single site, where more specific and direct interaction may occur between different species. Aquatic gastropods, for example, may be highly selective with respect to their choice of macrophyte substrate in a given water body at different times of the season (Pip and Stewart 1976).

In conclusion, the ecology of freshwater gastropods may show regional variation, since some species appear to undergo a certain amount of adaptation to the environmental characteristics prevailing in Shield sites. The gastropods typical of Shield waters form a tightly-knit association cluster which reflects to some degree the qualities of the habitats where the species tend to occur. The gastropods also form numerous associations with Shield macrophytes; in some cases these appear to be the result of similar ecological affinities.

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Received 9 June 1983
Accepted 15 April 1984

Observations on Foxes, *Alopex lagopus* and *Vulpes vulpes*, and Wolves, *Canis lupus*, on the Off-Shore Sea Ice of Northern Labrador

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Andriashek, Dennis, Henk P. L. Kiliaan, and Mitchell K. Taylor. 1985. Observations on foxes, *Alopex lagopus* and *Vulpes vulpes*, and Wolves, *Canis lupus*, on the off-shore sea ice of northern Labrador. Canadian Field-Naturalist 99(1): 86–89.

Observations of Arctic Foxes (*Alopex lagopus*), Red Foxes (*Vulpes vulpes*) and Wolves (*Canis lupus*) were made on the offshore sea ice in northern Labrador during late winter and early spring from 1975 to 1979 and again in 1982. Red Foxes, one Arctic Fox and one Wolf were scavenging on Ringed Seals (*Phoca hispida*) which had been killed by Polar Bears. (*Ursus maritimus*). Foxes showed a preference, as did Polar Bears, for active ice areas and exposed coastlines. Some predation of Ringed Seal pups by Arctic Fox occurred. Scavenging of unutilized seal remains and predation of newborn pups is probably important to survival of foxes and may also be significant to Wolves along the northern Labrador coast.

Key Words: Arctic Fox, *Alopex lagopus*, Red Fox, *Vulpes vulpes*, Wolf, *Canis lupus*, Labrador, sea ice.

Arctic Foxes, *Alopex lagopus*, and Wolves, *Canis lupus*, have been reported preying and scavenging upon Ringed Seals, *Phoca hispida* (Smith 1976; Stirling and Archibald 1977). However, the extent to which this occurs throughout the Arctic, and its ecological significance, are poorly documented. We know of no previous records for such activity for the Red Fox, *Vulpes vulpes*. This paper summarizes observations of foxes and Wolves on the sea ice along the northern coast of Labrador in late winter and early spring.

Study Area and Methods

Observations of foxes and Wolves were made during surveys for Polar Bears along the Labrador coast between Killinek Island and White Bear Island (Stirling and Kiliaan 1980) during annual trips of up to three weeks duration between February and May from 1975 through 1979 and in 1982 (Table 1; Figure 1). We flew in a Bell 206 B helicopter at about 150 km/h at altitudes varying between 30 m and 100 m.

In 1982, we kept records on the distance travelled over the following sea ice habitats (from Stirling et al. 1981).

- Type 1 Snow covered, stable, flat ice areas with drifted pressure ridges. Suitable for seal lairs.
- Type 3 The floe edge where leads are greater than 1 km wide or ice cover is less than 7/8.
- Type 4 "Active zones" where the ice moves and cover is 7/8 or more.
- Type 7 Deep bays and areas of smooth land-fast ice, with fewer ridges than Type 1, such as Hebron Fiord.
- Type 8 Exposed coastline which is bound by less than 7/8 ice cover; common along Northern Labrador coast during offshore winds.
- Type 9 Floe ice of less than 7/8 cover.

Ice conditions along the Labrador coast, and the extent of the land-fast ice in particular, appeared to be similar between years. The coastal edge of the land fast ice usually comprised a strip of active ice of varying widths which broke up, rafted and/or refroze subject to wind directions. Northwesterly winds usually pushed ice offshore into the Labrador Sea resulting in an exposed coastline (Habitat Type 8) and a narrow strip of active ice at mouths of bays. When winds prevailed from the northeast, ice blew in to the coast resulting in expanses of many kilometers of active or Type 4 ice offshore.

Whenever possible, foreflipper nails and teeth were collected from seal carcasses to determine the age of the animal. The age of newborn Ringed Seal pups could be confirmed by the presence of white lanugo. All seal carcasses which had Polar Bear tracks associated with them were presumed to have been killed by Polar Bears.

Results and Discussion

Most of the fox activity was concentrated in the active ice interface (Ice Type 4) between the land-fast ice and the drifting pack-ice. Similarly, Polar Bears and their tracks were distributed on land-fast ice or floes within one kilometer of the floe edge (Stirling and Kiliaan 1980). All seal kills seen in 1982, and most of those seen in the previous years, were also found in the active ice interface zone. Wolves, in most years, were more common in the active ice zone (Ice Type 4) and the more stable land-fast drifted pressure ice interface commonly found near the mouths of bays (Ice Type 1; Figure 1). In 1982 the only Wolf seen was on ice Type 1 (Table 2).

During the 1976–1978 and 1982 surveys, a total of 24 Red Foxes and four Arctic Foxes were observed on the sea ice, mostly between Hebron Fiord and Seven

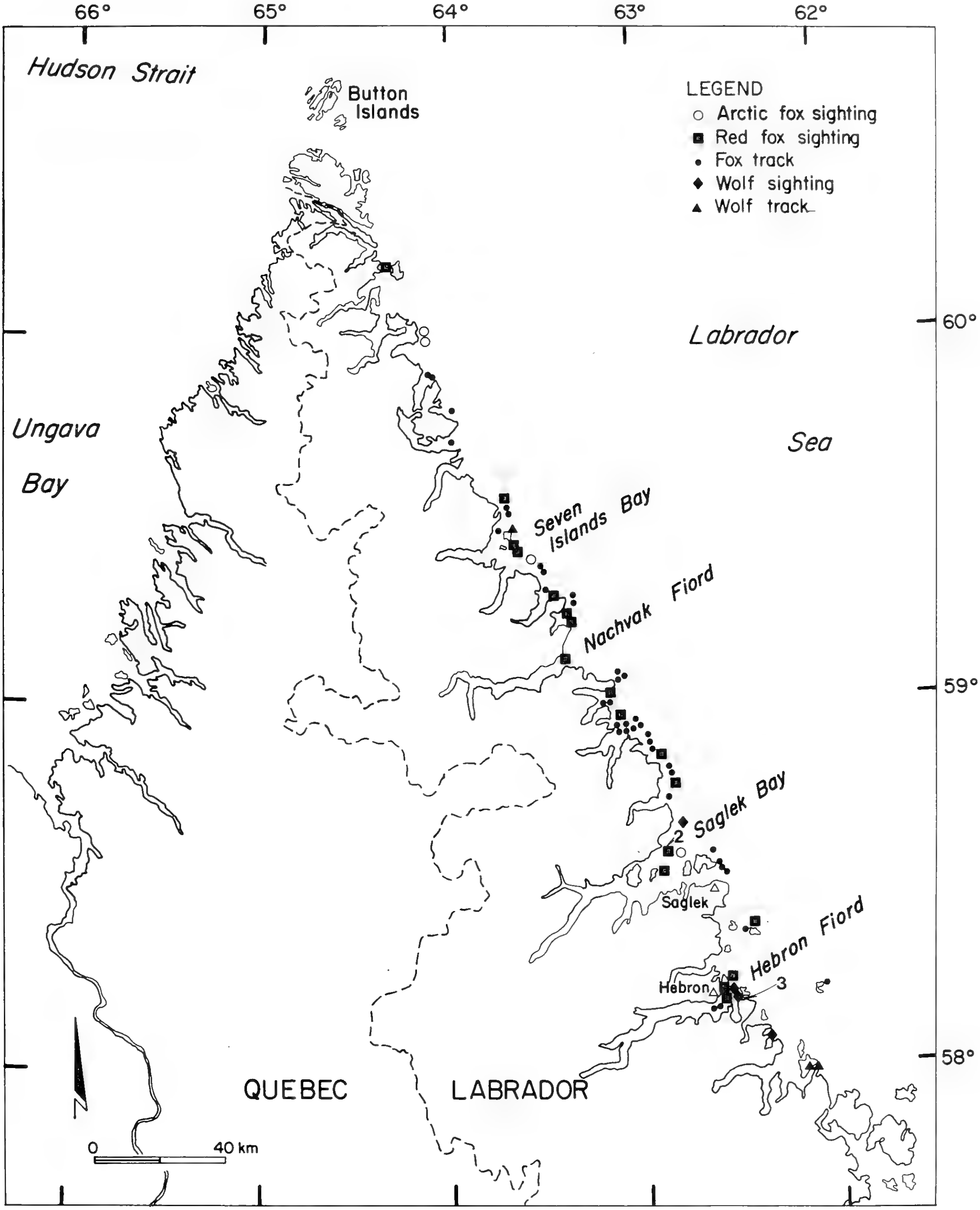

FIGURE 1. Fox and Wolf observations on the northeast Labrador coast 1976–1978 and 1982. Five Red Foxes are not included because exact locations are not known.

TABLE 1. Sightings of foxes, wolves and their tracks in 1975–1979 and 1982 on the northern Labrador coast.

			Number of Sightings					
Year	Dates	# km flown	Red Fox	Arctic Fox	Fox Tracks*	Wolves	Wolf Tracks*	Comments
1975	21–23 May	—	0	0	0	0	0	Tracks melted
1976	24–30 March	4325	6 (0.14/100 km)	0	—	1 (0.02/100 km)	3+	—
1977	23–28 March	2515	4 (0.16/100 km)	0	38 (1.51/100 km)	0	0	—
1978	19 March–3 April	2910	9 (0.31/100 km)	2 (0.07/100 km)	—	4 (0.14/100 km)	—	—
1979	17 March–27 March	3757	0	0	0	0	0	Deep soft snow on sea ice
1982	18 February–7 March	2554	5 (0.20/100 km)	2 (0.08/100 km)	10 (0.39/100 km)	1 (0.04/100 km)	2 (0.08/100 km)	—
	TOTAL	16062	24 (0.15/100 km)	4 (0.02/100 km)	48 (0.30/100 km)	6 (0.09/100 km)	2 (0.01/100 km)	—

*Tracks seen at the location an animal is sighted are not included.

TABLE 2. 1982 sightings of foxes, wolves and their tracks categorized by ice type habitats, and including number km flown in each.

			Number of Sightings					
Ice type	km flown for animal sightings	km flown for track sightings	Red Fox	Arctic Fox	Fox Tracks	Wolf	Wolf Tracks	Seal Kill
1	79	79	0	0	0	1 (1.27/100 km)	2 (2.53/100 km)	—
3	107	107	0	0	0	0	0	—
4	1654	1592*	3 (0.18/100 km)	2 (0.12/100 km)	8 (0.5 /100 km)	0	0	5 (0.30/100 km)
7	308	308	1 (0.32/100 km)	0	0	0	0	—
8	273	273	1 (0.37/100 km)	0	1 (0.37/100 km)	0	0	—
9	133	133	0	0	0	0	0	—

*Poor weather conditions precluded sighting tracks for 62 km.

Islands Bay. During the same periods six Wolves were seen on the sea ice in the Saglek Bay and Hebron Fiord areas (Figure 1, Table 1). No foxes or Wolves were seen on the ice during the surveys in 1975 and 1979. Red Foxes and Wolves are easier to see than Arctic Foxes because of their larger size and contrasting coloration, but we cannot measure this bias. Even so, we believe that most of the canids on the sea ice along the Labrador coast were Red Foxes.

Because foxes and Wolves were disturbed by the approaching helicopter, most animals were running when first sighted. We assumed that an animal running from carrion had been scavenging on it. Five Red Foxes and one Arctic Fox were seen scavenging seal carcasses. Two Red Foxes scavenged an unidentified sea bird frozen in young ice at Saglek Bay. A single Wolf was observed scavenging a seal killed in Saglek Bay, but Wolf tracks were not seen at other seal kills. In 1976 Wolves apparently killed and partially consumed three caribou about 200 m offshore of Kennard Island, Seven Islands Bay.

In 1982, we investigated four of the five seal kills we saw. Two kill sites which were about a day old had a Red Fox at one and an Arctic Fox at the other. Only bear and fox tracks were seen at the third site, an old kill. A family of Polar Bears was still present at the fourth kill, a fresh one which foxes had not yet visited.

We found only one instance of predation; a Ringed Seal pup killed in its subnivean lair by an Arctic Fox. One Red Fox was observed trotting towards a group of Ringed Seals hauled out approximately 400 m distant, and another was recorded in an area where Ringed Seal breathing holes were open and numerous. It is unlikely that either Arctic Foxes or Red Foxes prey on seals larger than newborn pups (Smith 1976). The peak of the Ringed Seal pupping season in Cumberland Sound, about 800 km north of our study area, occurs in late March or early April (Smith 1973) and is likely little different along the northern Labrador coast. Thus, most of our surveys would have ended when pupping was near its peak. Most fox predation on seal pups would have to occur at a time near the peak of pupping before the pups have grown too large for foxes to be able to kill.

During the periods when we observed foxes and wolves on the sea ice, small mammals and birds were less accessible and probably less abundant because of snow cover and seasonal changes in populations. Few large land mammals, such as caribou, winter in the northern coastal area of Labrador (Dauphiné et al. 1975) so there is little opportunity for foxes to scavenge on terrestrial Wolf kills. Remains of Ringed Seals left on the sea ice by Polar Bears, and to a lesser extent live newborn pups, appear to be an important source of food which influences fox and Wolf distribution along the northern Labrador coast during winter and spring.

Acknowledgments

We thank Esso Resources of Canada Ltd., Canadian Wildlife Service, Petro-Canada and the Polar Continental Shelf Project for the support which made this study possible.

Newfoundland and Labrador Wildlife Service and in particular Stuart Luttich provided invaluable logistic support and advice. We thank B. Beckie, R. Brading, J. Goodyear, J. Innes, J. Lunn, S. Luttich, and P. Pellerin for their assistance in the field. W. Calvert, H. Cleator and I. Stirling provided valuable comments on drafts of the manuscript.

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Received 13 July 1983
Accepted 29 May 1984

Responses of Wolves, *Canis lupus,* to Simulated Howling on a Homesite During Fall and Winter in Jasper National Park, Alberta

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Dekker, Dick. 1985. Responses of Wolves, *Canis lupus,* to simulated howling on a homesite during fall and winter in Jasper National Park, Alberta. Canadian Field-Naturalist 99(1): 90–93.

During fall and winter 1980-1983, simulated Wolf (*Canis lupus*) howls were used to contact Wolves on semi-open Montane grasslands and river flats in Jasper National Park, Alberta, near a known Wolf-denning and rendezvous site. Twelve times a pack of 4-9, including the same recognizable alpha pair, was observed. Only during the first sighting did the pack respond by coming toward the observer's lookout hill. Thereafter it did not approach and only sometimes howled. Of 14 single Wolves seen 12 trotted into the direction of the observer's lookout and howled.

Key Words: Wolves, *Canis lupus*, howling, homesite, winter.

Human simulations of Wolf (*Canis lupus*) howls have been used by many field researchers to elicit howling responses from Wolves near dens and rendezvous sites in forested habitats during summer (e.g., L. N. Carbyn 1980. Ecology and management of wolves in Riding Mountain National Park, Manitoba. Canadian Wildlife Service internal report. 184 pp.). Harrington and Mech (1982) recently reported on the fall and winter use of Minnesota homesites by separated pack Wolves, which replied significantly more often to simulated howling there than anywhere else, whereas packs as a unit never returned to the homesites after abandonment in late summer. Visual observations described in this paper of single Wolves and packs responding to simulated howling on a semi-open homesite in Jasper National Park, Alberta, complement and in part differ from the findings of Harrington and Mech (1982) who used radio-telemetry to study the Wolves and could not see them in the forested terrain which afforded limited visibility.

Study Area and Methods

The study area includes roughly 3 km^2 of open gravelly river flats and a mosaic of Montane grasslands interspersed with stands of predominantly White Spruce (*Picea glauca*) in the Athabasca Valley of Jasper National Park, Alberta, Canada. Base elevation is approximately 1000 m. For a more detailed description of the area and its large-mammal fauna see Cowan (1947) and L. N. Carbyn (1975. Wolf predation and behavioural interactions with elk and other ungulates in an area of high prey diversity. Canadian Wildlife Service internal report. 233 pp.). A pack of 6–9 Wolves denned in the study area in 1980, 1981 and 1982 and used the meadows as a rendezvous site in the summers of 1980 and 1981 (Dekker 1981, 1982. Unpublished Report for Alberta Fish and Wildlife Division. 28 pp.).

During the fall and winters of 1980-1983, at irregular intervals ranging from one to ten weeks, I made 23 hiking and camping trips of 2-5 days duration to the study area (Table 1). In morning and evening I spent 0.5 to 2 hours on a partly-forested hill overlooking the meadows and river flats. At each visit to the hill, totalling 94, I howled one to five times, using a "breaking" type of howl (Harrington and Mech 1978), listened for answers and scanned the area through 9× binoculars. Before each of 79 of these howling sessions I did not know whether Wolves were present in the area. On 15 occasions I had just seen Wolves or heard their howls before I howled. If wolves were sighted I watched them through a 20× telescope for as long as they remained in view. I usually sat or stood by a clump of spruce trees and made no attempt at complete concealment. If Wolves responded to my howls, I did not howl again unless the Wolves were far away at first contact and stayed out of sight. I always howled from the same hill, camped at its base on the same spot, and never approached or followed the Wolves that I saw. Field observations were written down at the end of the day or upon arriving home.

Results

I sighted Wolves on 25 dates (Table 1), of which 12 involved a pack numbering from 4 to 9 members. What I assumed to be the alpha male of this pack, because he was usually in the lead, was a very large Wolf, creamy white with grey back, dark facial markings and a prominent black tail tip. A much smaller Wolf that I believed to be the alpha female was silver-grey with black rump and tail, tipped with grey. Both of these animals were always seen with the pack, except on one date when the male was absent and the silver-grey wolf was in the lead. Other pack members changed over the four-year period 1980–1983 and ranged in color from pure white to black, but none looked exactly like either of the alpha pair.

In the early morning of 10 November, 1980, the date of my first sighting, the pack approached over the

TABLE 1. Observation days, Wolves sighted and number of replies to simulated howling. Figures in brackets represent number of packs and single Wolves that approached the observation hill after observer howled.

		Wolf Sightings			
Month	Observation Days	Packs	Replies	Singles	Replies
October	8	2	—	2 (1)	2
November	13	3(1)	1	6 (5)	5
January	3	—	—	—	—
February	21	4	1	3 (3)	2
March	33	3	2	3 (3)	3
Total	78	12(1)	4	14 (12)	12

meadows just after I had howled once. At a distance of about 0.7 km, some of the Wolves hesitated and gazed into my direction. Eventually, all entered a belt of trees at the base of the lookout and presently some of the Wolves reappeared on the semi-open crest of an adjacent hill, an estimated 0.6 km away, where they remained for about two hours. About an hour after their arrival, I saw a limping Wolf, twice howling softly, traverse the meadows in the same general directin as the pack had gone, and enter the woods where the pack was resting. Presently, the pack howled and single Wolves kept on howling for about 30 minutes. When I howled in late afternoon, the pack answered from far away.

On two subsequent dates, after I had howled, the pack emerged from the woods on the far end of the meadows, about 1 km from my lookout. Several members howled briefly, or ran a little ways into the direction of my lookout, then they returned to the woods and the entire pack disappeared from view. On one of these occasions I had heard the pack howl before I climbed the lookout hill. On all other nine occasions that I observed the pack, I had spotted it before I howled; five times it was travelling through the area, and four times it was resting on the meadows or on the frozen river. Shortly after the travelling Wolves were out of view, I howled but obtained no response. Upon my howl some resting Wolves lifted their head and gazed into the direction of the lookout. In one instance, several members, probably pups, howled. In three sightings the pack got up, followed the alpha male and moved out of view in an unhurried fashion. In one instance the Wolves remained where they were and resumed sleep after they had looked in my direction briefly and probably saw me. On four additional dates on which I did not see the pack, I heard its distant howl after I called, but no Wolves came into view nor did I hear additional howls from closer by.

I observed 14 single Wolves. Four of these were spotted travelling before I had howled. When I howled, while they remained in view, two briefly halted and howled about seven times before resuming travel. The third changed direction and trotted into the direction of my lookout hill, vanishing into the woods at the base and reappearing on an adjacent hill where it howled about 20 times. The fourth, which looked like the alpha male, was out of view in between the trees when I howled. It emitted a short low howl and, as its tracks indicated, approached me within 100 m, then turned away.

Of ten single Wolves that I "howled up", several appeared to have come from quite far away judging by the sound of their first howl. Others did not howl before coming into view on the meadows where they may have been bedded down when I called. All of these ten single Wolves trotted into the direction of my lookout. Three ascended the hill and came within 50–100 m of me before turning about. The others appeared to see me while still 0.5–0.8 km away on the meadows. Seven reappeared on the open crest of an adjacent hill where they howled 6–30 times and three barked as well. Eventually they wandered off between the trees. Of two Wolves that did not howl, one appeared to be the same individual I had called up in the morning of the same day when it approached as well as howled. The other Wolf entered the woods below my lookout and neither reappeared nor howled.

On 14 March 1982, P. DeMulder and I witnessed the apparent reunion of a separated pup with the pack. The evening before, 2 km south of the lookout hill, we had observed the alpha pair with four pups of the year, all sandy-colored with a small amount of black on the tail tip. In the early morning, the alpha pair with two pups passed by our camp and disappeared into the woods about 1.5 km to the north. An hour later, I howled from the lookout and a single howl sounded far to the south, while presently a pack responded far to the north. Minutes later, a single howl sounded much closer to us in a south-easterly direction and a sandy-colored Wolf galloped across

the meadows northwards. It crossed a belt of spruces and reappeared on the frozen river about 0.8 km to the north where it paused and howled once. Gusty winds prevented us from hearing its howl. The pack probably howled also but we were unable to hear it. The pup suddenly ran to the woods and entered where we had seen the pack enter an hour before. Five to ten minutes later, six Wolves emerged from the woods and bedded down on the snow-covered river ice. They were the alpha pair and four sandy-colored Wolves with black-tipped tails.

I had the impression that the Wolves had "accepted" my frequent presence in the area and had adjusted to it. I often found tracks within 50–100 m of my camp, but a game trail by which I ascended the lookout and on which I had frequently found Wolf sign prior to 1980, rarely showed evidence of use thereafter. The pack showed no overt fear when watching me from a distance. When I met it at dusk one day, the alpha male barked at me in a prolonged threat sequence (Joslin 1966), similar to the barking of alpha Wolves I encountered on summer rendezvous sites elsewhere in Jasper Park (D. Dekker 1981, 1982. Unpublished Report for Alberta Fish and Wildlife Division. 28 pp.).

Discussion and Conclusion

Because the pack approached me only the first time I howled (n = 12) and did not do so again, it is possible that it may have recognized some of my subsequent howls and associated them with my presence on the lookout. Additionally, during some sightings the Wolves probably spotted me soon after I howled and perhaps did not approach as a consequence of seeing me. However, they did not approach either in two instances when I was certain that the alpha pair and other pack members had not seen me. Moreover, in the only instance when the pack did approach me, it may not have done so in direct response to my howl but because it happened to be travelling into my direction. The late arrival of the crippled Wolf points to the probability that the pack had been on the move for some time. A similar sighting of a travelling pack silently approaching a human howler was recorded by me from a non-homesite location elsewhere in Jasper National Park (Dekker 1983). Probably, resident Wolf packs on their homesites are not interested in searching out the source of every distant howl, be it lone Wolf or simulation. To my knowledge, there are no recorded instances of Wolf packs approaching human howlers near summer homesites. However, several field researchers reported the approach of single Wolves and pairs (Joslin 1966, Harrington and Mech 1979, Carbyn 1980, Canadian Wildlife Service internal report).

The eager responses of single Wolves reported in this paper were probably indicative of their desire to join conspecifics or pack mates. Although I could not be certain about the social status of the single Wolves, several were probably pups that had returned to the homesite after being separated from their pack. In Minnesota, during fall and winter, separated members of two radio-collared packs often returned to a homesite and howled readily in response to simulated howling. It would seem that they should do so in order to locate their pack, however the pack as a unit never returned after abandonment in late summer (Harrington and Mech 1982). Therefore, the observations reported here are noteworthy as the Jasper pack frequently returned to its homesite during fall and winter. Also the Wolf pack studied by Carbyn (1975, Canadian Wildlife Service internal report) elsewhere in Jasper National Park frequently returned to its denning and rendezvous site between 1 November and 31 March.

The major difference between winter use of homesites between Minnesota Wolf packs, which did not visit the sites at all (Harrington and Mech 1982), and Jasper Park packs may be explained by homesite location in relation to travel and hunting routes. The Minnesota packs usually did not hunt or travel near their homesites (Harrington, personal communication), whereas the homesite of the Jasper pack I studied was at a major ungulate wintering location where Wolves travelled and hunted often. Recently-made tracks of a pack were found on all but two of my visits there and I often saw evidence, such as fresh beds in snow, that the Wolves slept or rested on the meadows during the night and left near dawn.

Acknowledgments

Since 1982, this study was supported by grants from the Canadian Wolf Defenders and the Alberta Parks, Recreation and Wildlife Foundation. P. DeMulder and B. Genereux accompanied me on several trips afield. L. N. Carbyn and F. H. Harrington critically read the manuscript, made helpful comments and supplied relevant literature.

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Received 5 July 1983
Accepted 16 July 1984

Plants New to Alberta from Banff and Jasper National Parks

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Achuff, P. L., and I. G. W. Corns. 1985. Plants new to Alberta from Banff and Jasper national parks. Canadian-Field Naturalist 99(1): 94–98.

During an ecological land classification of Banff and Jasper national parks, five species of plants previously unknown to Alberta were discovered: *Hippuris montana* (Mountain Mare's-tail), *Sedum divergens* (Spreading Stonecrop), *Tsuga heterophylla* (Western Hemlock), *Vaccinium ovalifolium* (Oval-leaved Blueberry), and *Aruncus sylvester* (Sylvan Goat's-beard). These Alberta occurrences extend the known ranges of all five species eastward from central British Columbia. In addition, Alberta range extensions of 22 rare vascular species were recorded.

Key Words: Alberta, new species, rare plants, range extension, Banff, Jasper, Rocky Mountains.

Five species of plants (*Hippuris montana, Sedum divergens, Tsuga heterophylla, Vaccinium ovalifolium*, and *Aruncus sylvester*) previously unknown to Alberta were discovered during an ecological land classification (Holland and Coen 1982) of Banff and Jasper national parks (BNP and JNP). These Alberta occurrences extend the known ranges of all five species eastward from central British Columbia. The species occur in the Subalpine zone (Alpine for *Hippuris montana*) in the Main Ranges, usually close to the Continental Divide. These areas are moister than either the lower elevation Montane zone or the Front Ranges to the east (Holland et al. 1982). They are also cooler than the Montane in summer and have warmer extreme minima because arctic air masses in winter intrude from the east along major river valleys at low elevations, creating temperature inversions. Thus, these areas are among the most mesic or temperate in the parks and climatically resemble areas of central British Columbia where these species also occur.

In addition, Alberta range extensions of 22 rare vascular species were recorded. The definition of rare species used here follows that of Argus and White (1978) and Packer and Bradley[1]. The vascular flora of BNP and JNP comprises about 1000 species (Holland and Coen 1982) that belong to several floristic elements based on the geographic distributions of the species. The flora contains primarily two elements: boreal and cordilleran. Ogilvie (1962) noted that many species of the cordilleran element in the Rocky Mountains were restricted to southwestern Alberta, south of about 50° N. Of the 107 species that he listed as occurring in Alberta only in this southern area, more than a third are now known to occur further north, as reported here or by Packer (1983). Nineteen of the 22 extensions reported here are extensions further north in Alberta along the Rocky Mountains. The exceptions are *Dryopteris fragrans, Salix reticulata* ssp. *reticulata*, and *Saxifraga nivalis*.

It appears premature to attempt an interpretation of the biological significance of this new information, for we conclude that the ranges are still poorly known. The backcountry of the parks has seldom been visited by plant collectors, particularly so in areas of difficult access along the Continental Divide. The collections made here were largely incidental to fieldwork for a reconnaissance land classification that focused on representative, extensive landscapes. Only limited collecting occurred in rare or unusual habitats that are more likely to contain rare or unusual species. A more thorough effort is required to confirm species distribution patterns and, conversely, the reality of gaps in species distributions.

Nomenclature mainly follows Packer (1983). Voucher specimens are deposited in the herbarium of the Northern Forest Research Centre, Edmonton, Alberta (CAFB). Collectors' names are abbreviated as follows: CC (C. Chernoff), DK, (D. Karasiuk), IC (I. Corns), JC (J. Cuddeford), JD (J. Dyck), JE (J. Marsh), JM (J. McLean), KS (S. Kojima), LC (L. Cole), PA and PLA (P. Achuff), and SJ (S. Scott). Collections are listed in chronological order under each species and national park.

Species New to Alberta

Hippuris montana Ledeb., Mountain Mare's-tail (Figure 1): *Hippuris montana* was found in JNP along shallow stream margins and in wet mossy depressions in the Alpine zone. JNP: Catacombs Mtn. 52°27′N 117°45′W (IC s.n. 28 Sep 76), Lick Ck. 52°27′N 117°52′W (IC s.n. 19 Aug 77), Divergence Ck. 52°32′N 118°00′W (IC s.n. 20 Sep 77), Miette Pass

[1]Packer, J G., and C. Bradley. 1978. A checklist of the rare vascular plants of Alberta with maps. Alberta Recreation and Parks. Unpublished report.

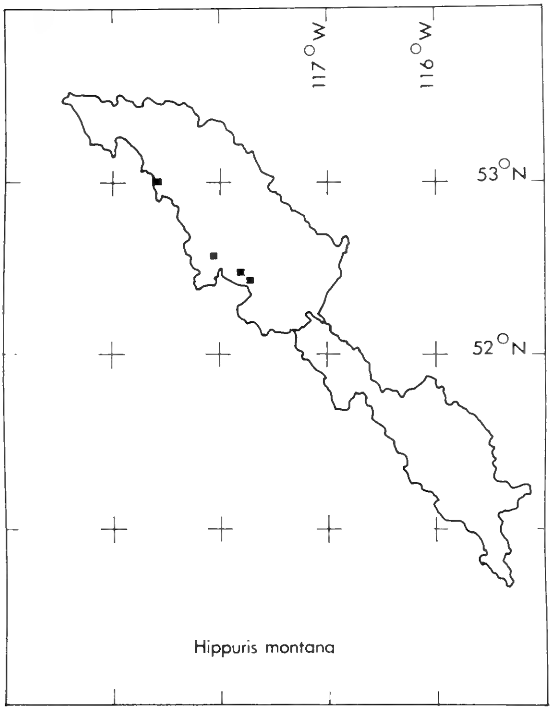

FIGURE 1. *Hippuris montana* collections from Banff and Jasper national parks.

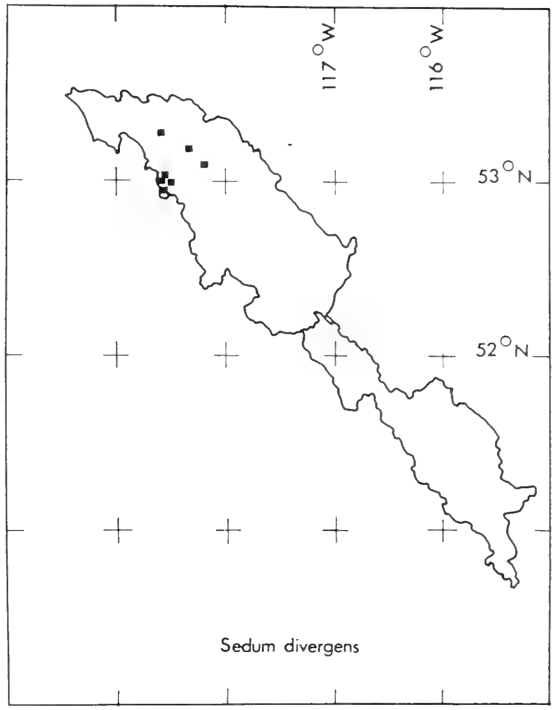

FIGURE 2. *Sedum divergens* collections from Banff and Jasper national parks.

53°03′N 118°37′W (IC s.n. 29 Jul 79). It occurs otherwise from the Aleutian Islands to the western Northwest Territories, south to the Olympic and Cascade mountain ranges of Washington.

Sedum divergens Watson, Spreading Stonecrop (Figure 2): *Sedum divergens* occurs on rocky slopes and ledges and on avalanche slopes in the Subalpine zone of JNP. A map of the range of *Sedum divergens* by Murray (1980) indicates that its range extends into Alberta. Alberta is not mentioned in the text, however, nor does Clausen's (1975) monograph of *Sedum* indicate any occurrences of this species in Alberta. We have not been able to find any previous collections of *Sedum divergens* from Alberta and conclude that the map line in Murray (1980) indicating an Alberta occurrence was misplaced. JNP: Mt. Bridgland 52°55′N 118°31′W (IC s.n. 9 Sep 77), Mt. Thornton 53°09′N 118°16′W (PLA 3651), The Ranee 53°11′N 118°40′W (PLA 3682), Upright Pass 53°07′N 118°46′W (IC s.n. 25 Jul 79), Miette Pass 53°01′N 118°39′W (IC s.n. 29 Jul 79), Derr Ck. 53°01′N 118°31′W (IC 9141), Corral Ck. 53°05′N 118°09′W (JE s.n. 10 Sep 79). *Sedum divergens* occurs otherwise from northeastern California to southern Alaska and eastward through central British Columbia.

Tsuga heterophylla (Raf.) Sarg., Western Hemlock (Figure 3): *Tsuga heterophylla* was found in moist *Picea engelmannii-Abies lasiocarpa* forests in the Subalpine zone of both parks. It occurs otherwise from southern Alaska to northern California and northwestern Montana. BNP: Castleguard R. 52°04′N 117°13′W (DK s.n. Jun 76), Mt. Coleman 52°04′N 117°13′W (PLA s.n. 7 Jun 77), Alexandra R. 52°05′N 116°59′W (JD s.n. 8 Aug 77). JNP: Fryatt Ck. 52°40′N 117°51′W (IC s.n. 17 Aug 77), Whirlpool R. 52°37′N 118°01′W (SJ s.n. 20 Sep 78).

Vaccinium ovalifolium J. E. Smith, Oval-leaved Blueberry (Figure 4): *Vaccinium ovalifolium* occurs in moist *Picea engelmannii-Abies lasiocarpa* forests in the Subalpine zone of both parks. It occurs otherwise from Alaska to Oregon and western Montana, in isolated areas of eastern Canada and the United States, and in parts of eastern Asia. BNP: Chephren L. 51°50′N 116°40′W (IC 7045), Arctomys Ck. 51°57′N 116°57′W (PA 7069), Glacier L. 51°54′N 116°59′W (PA 7094), Southeast Lyell Glacier 51°54′N 116°59′W (PLA s.n. 4 Aug 77). JNP: Canoe Pass 52°25′N 118°14′W (J.C. s.n. 9 Aug 77), Lick CK. 52°27′N 117°52′W (IC s.n. 19 Aug 77), Miette R. 52°56′N 118°35′W (IC 7080), Divergence Ck. 52°32′N

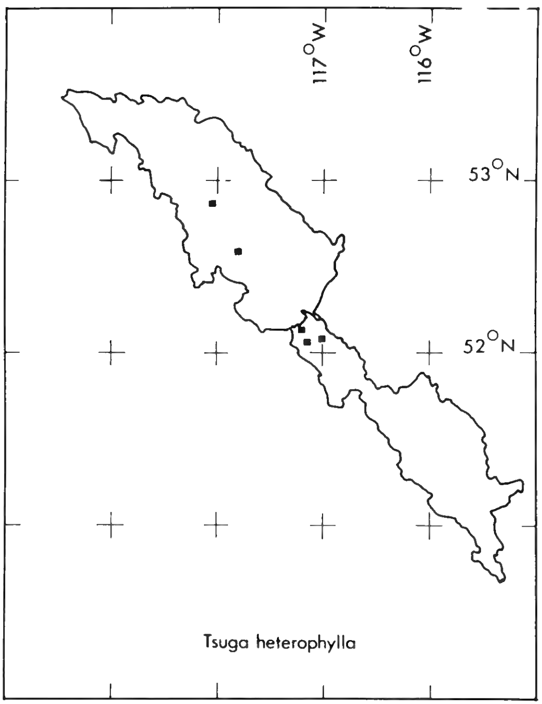

FIGURE 3. *Tsuga heterophylla* collections from Banff and Jasper national parks.

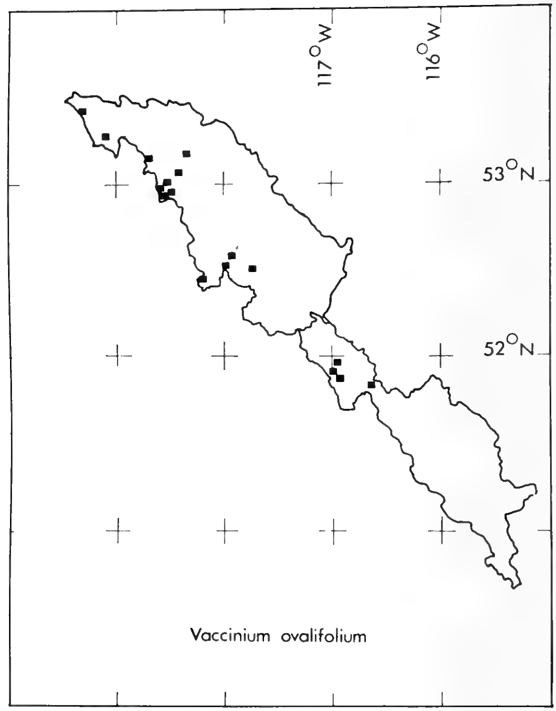

FIGURE 4. *Vaccinium ovalifolium* collections from Banff and Jasper national parks.

118°00′W (IC s.n. 20 Sep 77), Mt. Knight 53°04′N 118°26′W (IC 9080), Mt. Thornton 53°09′N 118°16′W (PLA 3649), Short Ck. 53°26′N 119°16′W (IC 9098), Snake Indian R. 53°15′N 118°52′W (JE 9103.1), Swoda Mtn. 53°18′N 119°13′W (LC s.n. 23 Jul 79), Upright Pass 53°07′N, 118°46′W (IC 9112), Mt. Beaupre 53°03′N 118°36′W (IC s.n. 29 Jul 79), Miette R. 53°01′N 118°31′W (IC s.n. 13 Aug 79), Geraldine Lakes 52°37′N 117°55′W (PLA 3724).

Aruncus sylvester Kostel., Sylvan Goat's-beard (Figure 5): *Aruncus sylvester* is found in moist *Picea engelmannii* forests of the Subalpine zone. It has otherwise been observed from central and southwestern British Columbia to Oregon. JNP: Smoky R. 53°22′N 119°15′W (IC s.n. 26 Jul 79). CAFB also has a collection from the Forestry Trunk Road along the Smoky R. valley north of JNP 54°29′N 118°16′W (KS s.n. 9 Jun 77).

Alberta Range Extensions

Arnica parryi Gray JNP: Portal Ck. 52°47′N 118°06′W (IC s.n. 27 Jul 75), extension of 130 km northwest from BNP.

Berberis repens Lindl. BNP: Johnston Ck. 51°15′N 115°50′W (JD s.n. 3 Jul 75), extension of 190 km northwest from Crowsnest Pass (49°37′N 114°36′W).

Botrychium lanceolatum (Gmelin) Angstr. JNP:

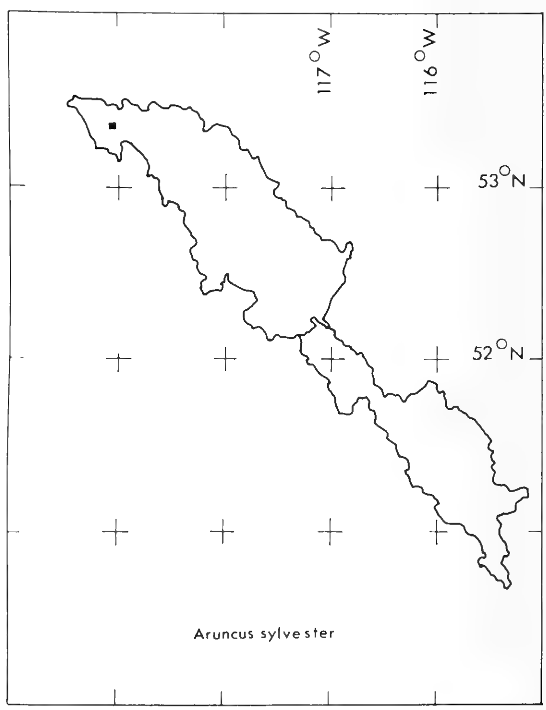

FIGURE 5. *Aruncus sylvester* collection from Jasper National Park.

Colonel Pass 53°05′N 118°45′W (IC 9121), extension of 260 km northwest from Larch Valley, BNP (51°20′N 116°15′W).

Clintonia uniflora (Schult.) Kunth. JNP: Smoky R. 53°22′N 119°15′W (IC s.n. 21 and 22 Jul 79), extension of 85 km northwest from Yellowhead Pass (52°53′N 118°27′W). The collection in Yellowhead Pass was made by J. Macoun in 1919. Otherwise, the nearest recent Alberta collections are from Waterton Lakes National Park about 600 km southeast.

Crepis intermedia Gray BNP: Cory Pass trail 51°11′N 115°39′W (PLA 3356), extension of 185 km northwest from Crowsnest Pass (49°37′N 114°36′W).

Draba kananaskis G.A. Mulligan JNP: Maligne L. 52°38′N 117°33′W (SJ 7053), extension of 250 km northwest from the Kananaskis Range.

Draba reptans (Lam.) Fernald BNP: Cory Pass trail 51°11′N 115°39′W (PLA 3354), extension of 180 km northwest from Stavely.

Dryopteris fragrans (L.) Schott JNP: Geraldine Lakes trail 52°37′N 117°55′W (IC s.n. 23 Jul 75), Maligne L. Rd. 52°52′N 117°45′W (JM s.n. 24 Jul 77), extension of 190 km northwest from Baseline Lookout (52°10′N 115°25′W). Previously known in Alberta from one collection at Baseline Lookout and otherwise on the Canadian Shield in the northeastern corner of Alberta.

Epilobium luteum Pursh JNP: Lynx Ck. 52°19′N 117°29′W (IC s.n. 4 Sep 76), extension of 95 km northwest from Bow Pass (51°43′N 116°29′W).

Erigeron flagellaris Gray JNP: Mina L. 52°53′N 118°07′W (IC s.n. 9 Jul 75), extension northwest 510 km from Lonesome L., Waterton Lakes National Park.

Festuca subulata Trin. BNP: Molar Mtn. 51°37′N 116°11′W (PA 7158), extension of 290 km northwest from Castle R.

Gaultheria humifusa (Grah.) Rydb. BNP: Glacier L. 51°54′N 116°59′W (PA 8168). JNP: Amethyst Lakes 52°43′N 118°16′W (JM 7072), Trapper Ck. 52°39′N 117°41′W (IC s.n. 13 Sep 77), Divergence Ck. 52°32′N 118°00′W (IC s.n. 20 Sep 77), Windy Castle 52°38′N 117°41′W (IC s.n. 21 Sep 77), Blue Ck. 53°25′N 118°55′W (IC 9051, LC 9165), Mt. Knight 53°04′N 118°26′W (IC 9079), Resthaven Icefield 53°27′N 119°25′W (IC s.n. 18 Jul 79), Smoky R. warden cabin 53°22′N 119°15′W (IC 9102), Miette Pass 53°01′N 118°38′W (IC s.n. 29 Jul 79), Mt. Davidson 52°26′N 117°29′W (PLA 3725), extension of 35-275 km northwest from Bow Pass (51°43′N 116°29′W).

Mimulus lewisii Pursh JNP: Snaring R. 53°05′N 118°45′W (JE s.n. 11 Aug 79), extension of 460 km northwest from Crowsnest Pass area (49°45′N 114°35′W).

Minuartia nuttallii (Pax) Briq. JNP: Corral Ck. 53°05′N 118°09′W (IC s.n. 8 Jun 77), Pyramid Mtn. 52°57′N 118°09′W (IC 7010), extension of 450 km northwest from Crowsnest Pass (49°37′N 114°36′W).

Osmorhiza chilensis Hook. & Arn. BNP: Mt. Murchison 51°56′N 116°42′W (PA s.n. 7 Jul 77). JNP: Maligne L. Rd. 52°52′N 117°38′W (IC s.n. 1 Sep 75), Mt. Christie 52°33′N 117°49′W (IC s.n. 11 Sep 75), extension of 400 km northward from Crowsnest Pass area (49°45′N 114°35′W).

Pteridium aquilinum (L.) Kuhn var. *pubescens* Underw. JNP: Short Ck. 53°26′N 119°16′W (IC 9092), extension of 355 km northwest from Banff (51°10′N 115°34′W).

Ranunculus verecundus B.L. Robins. JNP: Rocky R. 53°00′N 117°52′W (SJ 8046), extension northwest 285 km from Bryant Ck. (50°54′N 115°31′W).

Rorippa tenerrima Greene BNP: Owl L. 50°52′N 115°32′W (KS s.n. 11 Sep 76), extension of 150 km northwest from Crowsnest Pass.

Salix lanata L. ssp. *calcicola* (Fern. & Wieg.) Hult. BNP: Malloch Ck. 51°51′N 116°05′W (JC 8028.2). JNP: Whirlpool R. 52°37′N 118°01′W (JM s.n. 19 Sep 78, PA 9124). Extension of 110 km northwest and 50 km east from Saskatchewan R. Crossing (51°58′N 116°45′W).

Salix reticulata L. ssp. *reticulata*. JNP: Isaac Ck. 52°30′N 117°08′W (SJ 8036.2), Restless R. 52°46′N 117°22′W (IC 8046.3), Southesk L. 52°38′N 117°10′W (PA 9120), Waterfalls warden cabin 52°26′N 117°17′W (JE 9160), extension of 55 km south from Cardinal R. divide (52°55′N 117°22′W).

Saxifraga nivalis L. BNP: Sentinel Pass 51°20′N 116°14′W (KS s.n. 20 Aug 74), Sunset Pass 52°07′N 116°53′W (CC s.n. Jul 76), JNP: Wilcox Pass 52°15′N 117°13′W (IC s.n. 13 Jul 76), extension of 200 km southeast from Maligne Range.

Sorbus sitchensis Roemer JNP: Lynx Ck. 52°19′N 117°29′W (IC s.n. 4 Sep 76), Blue Ck. 53°20′N 118°38′W (IC s.n. 24 Jun 79), Smoky R. warden cabin 53°22′N 119°15′W (IC s.n. 23 Jul 79), extension of 235 km northwest from Bow Pass (51°43′N 116°29′W).

Acknowledgments

This study was part of an ecological land classification of BNP and JNP supported by Agriculture Canada and by Parks Canada, the Canadian Forestry Service, and the Canadian Wildlife Service of Environment Canada. We thank J. G. Packer for confirming some identifications, G. W. Argus and G. A. Mulligan for identification of *Salix* and *Draba* specimens, respec-

tively, and the curators of ALTA, CAN, DAO, and UAC for the use of their herbaria. We also thank the various collectors on the Banff-Jasper field team and H. Dudynsky for her assistance.

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Received 7 July 1983
Accepted 19 July 1984

Notes

The Brown Lemming, *Lemmus sibiricus*, in Alberta*

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Smith, Hugh C., and E. Janet Edmonds. 1985. The Brown Lemming, *Lemmus sibiricus*, in Alberta. Canadian Field-Naturalist 99(1): 99–100.

A specimen of a Brown Lemming, *Lemmus sibiricus*, found in Willmore Wilderness Park, Alberta, confirms the existence of the species in the province.

Key Words: Brown Lemming, *Lemmus sibiricus helvolus*, confirms, Alberta.

Until recently no specimens, fossil or modern, of the Brown Lemming had been known from Alberta. Burns (1980) described finding fossil evidence of this species in a late Pleistocene cave deposit at January Cave, southwestern Alberta, with an age between 23 000 BP and 1400 BP. Preble (1908: 182) gives the type locality for the subspecies, *Lemmus sibiricus helvolus*, as "from near the headwaters of one of the southern tributaries of Peace River, or between there and the Jasper House region." Subsequent authors have used this description and on the basis of it Soper (1964) included Alberta in the range of this subspecies, while others have not (Cowan and Guiquet 1965; Banfield 1974). Hall (1981: 829) is not definite. On the range map that shows the distribution of this species Alberta is not included, but in the Marginal Records section he states "also possibly Alberta: ?Rocky Mountain region of northwestern Alberta."

The confusion as to whether to include Alberta or not stems, we believe, from Preble's 1908 account for this species. Richardson (1828) first described the species on the basis of a specimen collected by Mr. Drummond in the "Rocky Mountains." In 1829 Richardson gave a further description of the location as "inhabiting alpine swamps, in latitude 56°" (Richardson 1829: 129). How Preble (1908) determined the type locality is not stated in his account, although he refers to Richardson's original description.

Recently one of us (EJE), while surveying Caribou (*Rangifer tarandus caribou*) by helicopter in Willmore Wilderness Park (Figure 1), had occasion to land near a small unnamed lake in the Park. While there, several bodies of a small rodent were observed washed up on shore. Twenty-one carcasses were counted. These animals were identified in the field as lemmings and one carcass was collected and brought to the Provincial Museum of Alberta for verification. The specimen, an adult male, was identified as *Lemmus sibiricus*. It is preserved in the Provincial Museum of Alberta collections as a skeleton (PMA No. 83.32.1). This specimen confirms the presence of this species in Alberta.

Lemmus sibiricus populations exhibit cyclic periods of abundance and scarcity (Rausch 1950; Krebs 1964). During periods of abundance individuals may swim lakes and rivers (Cowan and Guiguet 1965). This may account for the bodies that were observed on the lake shore.

The lake where this specimen was found is located in a remote area of Willmore Wilderness Park (53°32′N, 119°24′W) at an elevation of 1500 metres (5 000 feet). The lake drains into a small creek that feeds into the Smoky River and eventually into the Peace River. The sandy beach on which the lemmings were found was bordered by a hummocky, dwarf shrub-sedge meadow. This meadow was an opening in the Lodgepole Pine (*Pinus contorta*)/Engelmann Spruce (*Picea engelmannii*) subalpine forest and was approximately 4 km downstream from treeline.

It is interesting to note that Soper (1970) postulated that if Brown Lemmings occurred in Alberta, they would be found south of the source of the Kakwa River or Sheep Creek. This is approximately the area where the present specimen was obtained. It is hardly surprising that this species has not been encountered in Alberta before, considering the remote area in which it is found and the periodic fluctuation in population size known in this species. For example, as part of the ecological land classification study of Banff and Jasper National Parks (1974 to 1981) 330 snap traplines (66 000 trap nights) were run and no Brown Lemmings were trapped or observed (G. L. Holroyd

*Provincial Museum of Alberta Natural History Contribution 76

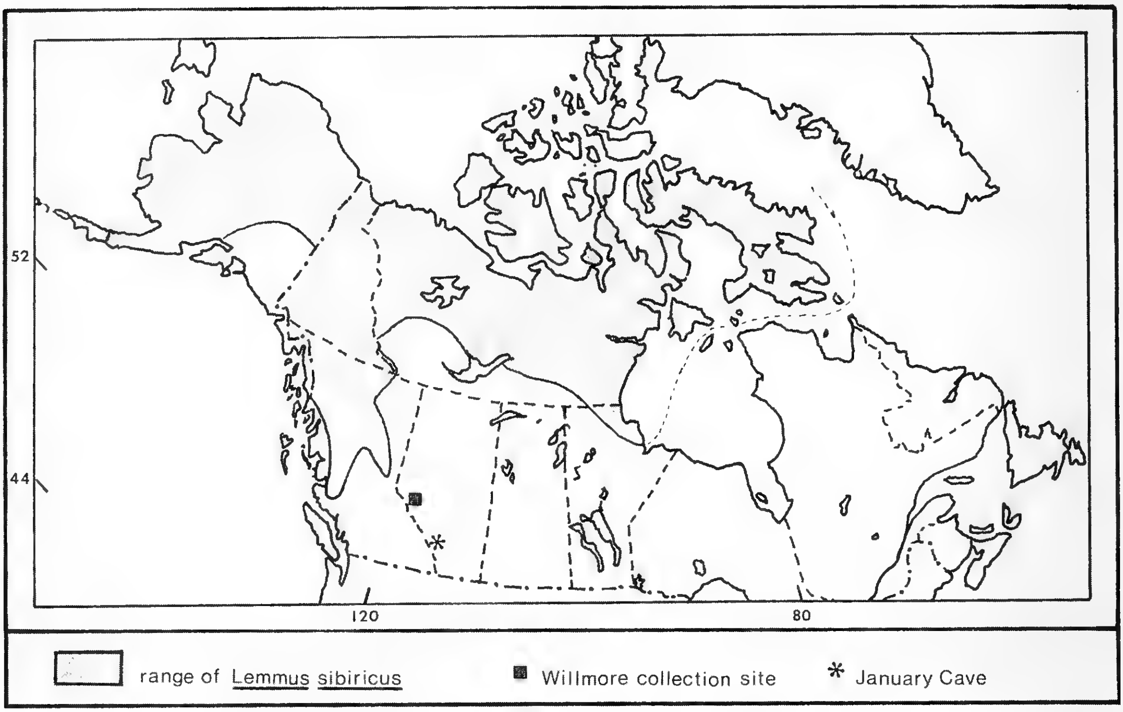

FIGURE 1. Range of *Lemmus sibiricus* modified from Hall (1981) and Burns (1980).

and K. J. Van Tighem. 1983. Ecological (Biophysical) Land Classification of Banff and Jasper National Parks Volume III: The Wildlife Inventory. Part A. Canadian Wildlife Service, Edmonton. Report for Parks Canada. 444 pp.). Until further survey work on small mammals is conducted in the area the systematic and distributional status of this species in Alberta will remain uncertain.

An addendum with respect to the type specimen of *Lemmus sibiricus helvolus* may be of interest. In the original description Richardson (1828) did not indicate where the specimen was housed and subsequent authors have not indicated the whereabouts of this specimen. One of us (HCS) contacted the British Museum (Natural History) to ask if the specimen was housed in their collection. Mr. P. D. Jenkins replied that the type specimen is housed in the British Museum as a study skin and skull with registration number 42.10.7.11.

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Received 16 December 1983
Accepted 24 August 1984

Male Fern, *Dryopteris filix-mas*, a Phytogeographically Important Discovery in Northern Saskatchewan

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Cody, William J., and Donald M. Britton. 1985. Male Fern, *Dryopteris filix-mas*, a phytogeographically important discovery in northern Saskatchewan. Canadian Field-Naturalist 99(1): 101–102.

Dryopteris filix-mas is reported as new to the flora of Saskatchewan based on a collection from the north shore of Lake Athabasca. The known distribution in Canada from Newfoundland to British Columbia is mapped. The report of *D. cristata* for northern Alberta is dismissed.

Key Words: *Dryopteris filix-mas, D. cristata*, Male Fern, Crested Wood Fern, Saskatchewan, Alberta

Dryopteris filix-mas (L.) Schott (Male Fern), is a species of worldwide distribution. In Europe, particularly in the western half, it is quite common. Elsewhere, the range is much disrupted. A map of the European distribution is given by Jalas and Suominen (1972), and the worldwide distribution by Hultén (1962).

In North America, *Dryopteris filix-mas* has long been known from largely disjunct populations in southern Greenland; western Newfoundland; Cape Breton Island, Nova Scotia; Gaspé Peninsula, Quebec; Bruce, Gray and Simcoe counties and Michipicoten Island in Lake Superior, Ontario; Waterton Lakes National Park, Alberta, and southern British Columbia, south to Maine, Vermont, Michigan, California, Arizona, Texas and South Dakota.

It was thus of great interest when a specimen was collected in northern Saskatchewan. Data are as follows: SASKATCHEWAN: north shore of Lake Athabasca, St. Joseph's Point, 59°30′N, 109°00′W, *K. Reading 80–37*, October 1980 (DAO). This is the first record for the species for the province of Saskatchewan, and is plotted on a map of the known Canadian distribution in Figure 1.

The specimen cited above was very short, the fronds measuring only from 22 to 24 cm in length, rather than up to 1 m as in plants found elsewhere in Canada. The fronds were however, characteristically those of *D. filix-mas*: the fruiting in the top half of the blade; the pinnae lance-linear, smaller below; the rachis and midribs with narrow, strongly toothed scales; the indusium glabrous; and the spores, under scanning electron microscope, similar to those illustrated by Britton and Jermy (1974) for plants from Grey County, Ontario; Cape Breton, Nova Scotia; and Custer State Park, South Dakota.

The colony consisted of a group of plants covering an area about one metre square growing out of a fracture in partial shade of a rock overhang. The rocks were granitic "Martin Formation; metasedimentary and metavolcanic" (Beck 1969). No other plants were found during a search of several square kilometres in the vicinity.

The depauperate aspect of our plant would indicate, at least to some extent, that the species is not growing under the best of conditions at Lake Athabasca. The species was certainly not common there. Thus it would appear that *D. filix-mas* reached the area when the climate was more amenable. It is in any event, a connecting link between the populations in southern British Columbia and southwestern Alberta, and the sites in the Great Lakes region. *Dryopteris filix-mas* should be added to the list of rare plants of Saskatchewan (Maher et al. 1979).

Several ferns have a restricted distribution in the vicinity of Lake Athabasca: *Woodsia scopulina* (Rocky Mountain Woodsia), a North American species primarily of western distribution; *W. oregana* (Oregon Woodsia), a North American species; *Pellaea atropurpurea* (Purple Cliff-brake), a North American species; and *Phegopteris connectilis* (Long Beech Fern), a circumpolar species. In addition Raup (1936) described *Deschampsia mackenzieana* (Tufted Hair Grass), *Salix brachycarpa* var. *psammophila* (Willow), *S. tyrrellii* (Willow), *S. turnorii* (Willow), *S. silicicola* (Willow), *Stellaria arenicola* (Chickweed), *Statice interior* (Thrift), and *Achillea megacephala* (Yarrow) from the vicinity of Lake Athabaska, thus indicating the area had some special character. Some phytogeographic aspects of the region were discussed by Raup (1946).

The occurrence of *Dryopteris filix-mas* at Lake Athabasca raised the question of whether a dot on the distribution map for *D. cristata* (Crested Wood Fern) in Carlson and Wagner (1982) might not also represent a collection of *D. filix-mas*. However, no specimen which would substantiate this dot has been found. W. H. Wagner (personal communication)

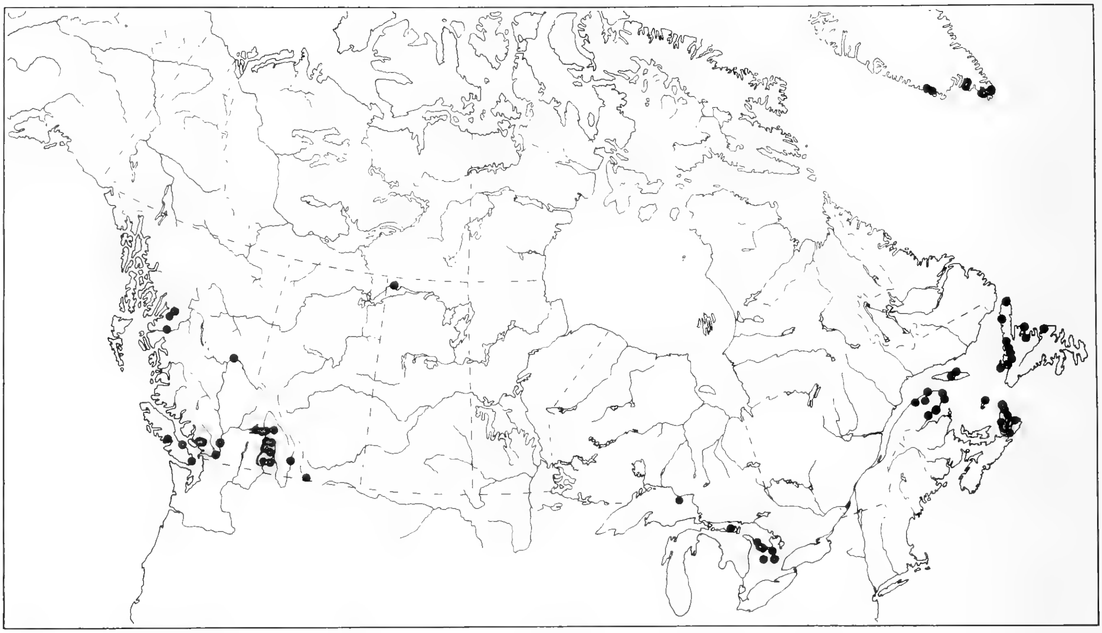

FIGURE 1. Known distribution in Canada of *Dryopteris filix-mas* (Male Fern), based on specimens preserved in DAO, CAN, UBC and V, TRT, G, MT (acronyms according to Holmgren et al. 1981).

reported that the dot was based on a report in Scoggan (1978). This in turn was based on the map in Hultén (1958). There is however no known basis for Hultén's record. Hultén did not personally visit the area and there is no record for *D. cristata* in the papers by Raup (1935, 1936), which treat this area. In addition, Packer (1983) has recorded *D. cristata* only from central Alberta in his *Flora of Alberta*. The record of *D. cristata* for northern Alberta by Carlson and Wagner (1982) should therefore be discounted not only for that species but also as a potential first record of *D. filix-mas* from Alberta.

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Received 30 November 1983
Accepted 27 June 1984

Introduction du boeuf musqué, *Ovibos moschatus*, au Nouveau-Québec et état actuel des populations en liberté

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Le Henaff, Didier. 1985. Introduction du boeuf musqué, *Ovibos moschatus*, au Nouveau-Québec et état actuel des populations en liberté. Canadian Field-Naturalist 99(1): 103–104.

Des observations effectuées en juin 1983 au Nouveau-Québec ont permis d'établir qu'à partir de 42 boeufs musqués libérés entre 1973 et 1978, une population, répartie en 15 groupes totalisant au moins 148 animaux, s'est développée et est en pleine extension.

Mots clés: Boeuf musqué, *Ovibos moschatus*, libérés, Nouveau-Québec.

Observations made in June 1983 in northern Quebec have determined that, from a release of 42 Muskox between 1973 and 1978, a population divided into 15 groups totaling at least 148 individuals has developed and is expanding.

Key Words: Muskox, *Ovibus moschatus*, introduction, New Quebec.

Au Nouveau-Québec, où pourtant aucun vestige de la présence du boeuf musqué n'avait été signalé (Banfield 1975), c'est en 1964 que débutèrent les premières démarches qui contribuèrent à l'établissement de la ferme d'élevage d'Umingnaqautik, érigée dans la région immédiate de Kuujjuaq (Fort Chimo). Les contacts entrepris auprès des autorités des Territoires du Nord-Ouest en vue d'obtenir la permission de capturer les boeufs musqués géniteurs aboutirent en mai 1967. En août de la même année, l'expédition de capture atteint Eureka sur l'île Ellesmere. Quinze boeufs âgés de quatre mois (12 femelles, 3 mâles) furent capturés, transportés puis débarqués à Umingnaqautik le 2 septembre. Le projet d'élevage s'amorça sous la responsabilité de Roger Lejeune, biologiste à la Direction générale du Nouveau-Québec, avec la collaboration de John J. Teal Jr., anthropologue et biologiste, alors directeur de l'Institute of Northern Agricultural Research d'Alaska.

Partisan ardent de l'implantation du boeuf musqué à l'état sauvage sur le territoire québécois, R. Lejeune contribua sans nul doute, même après son départ en 1972, à la décision de libérer les premiers animaux nés en captivité [Rapport d'évaluation du project d'élevage de boeuf musqué, Umingnaqautik, N.Q. (1967-1980). Centre d'études nordiques et faculté des sciences de l'agriculture et de l'alimentation. Université Laval, Québec, 169 pp, 1981; disponible au Centre d'études nordiques, Cité universitaire, Québec G1K 7D4]. De 1973 à 1978, 42 boeufs musqués, la plupart âgés de 1 à 2 ans, furent libérés, 16 dans la région de Tasiujaq (9 femelles, 7 mâles) et 26 au nord de Kuujjuaq (17 femelles, 9 mâles) (figure 1). Cependant, les observations qui ont suivi la libération n'ont fait à date l'objet d'aucune publication scientifique.

La dispersion du boeuf musqué au Nouveau-Québec, depuis son implantation, a été établie à partir de rapports d'observations provenant de différentes sources (Figure 1). Sur huit mentions différentes, quatre ont été à ce jour formellement vérifiées par l'auteur, soit celles de:

Ivujivik, où en 1976 une femelle a été photographiée;

Inukjuak, où en 1980 un mâle adulte a été abattu;

Tasiujaq, où en mai et en octobre 1982 respectivement 16 puis 13 animaux ont été observés par l'auteur;

Et au nord de Kuujjuaq, où, depuis 1980, un groupe composé actuellement de 15 animaux est régulièrement suivi par l'auteur.

Dans certains cas, comme à Inukjuak et à Ivujivik, les déplacements suivant la libération ont atteint 550 et 650 km respectivement. Ceci confirme les observations de Lent (1978) suggérant qu'en l'absence de barrière physique les boeufs musqués de 1 à 2 ans, libérés en petits groupes, sont susceptibles d'effectuer des déplacements erratiques sur de grandes distances.

Le succès de sa reproduction à l'état sauvage a été constaté pour la première fois en octobre 1980, au nord de Kuujjuaq: 3 femelles adultes furent observées en compagnie de 1 mâle adulte et de 2 veaux de 6 mois (C.E.N. 1981).

En juin 1983, nous avons effectué, pour la Direction de la faune terrestre du ministère du Loisir, de la Chasse et de la Pêche, un inventaire aérien systématique des régions de Tasiujaq et Kuujjuaq. Cet inventaire, réalisé en avion bimoteur DC-3 et vérifié au moyen d'un hélicoptère, a permis de dénombrer 148

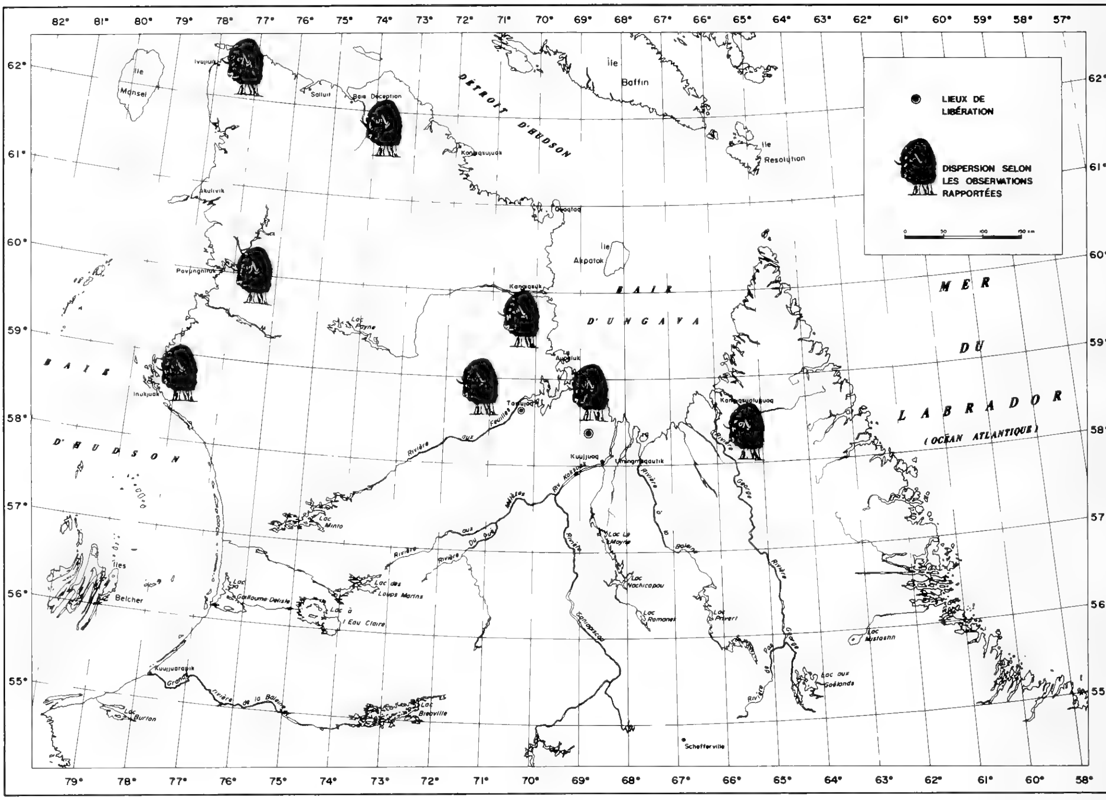

FIGURE 1. Dispersion du boeuf musqué au Nouveau-Québec [D. Le Henaff. 1982. Libérations et dispersion du boeuf musqué au Nouveau-Québec. La Direction de la faune terrestre, ministère du Loisir, de la Chasse, et de la Pêche - 150, boulevard Saint-Cyrille, Québec G1R 4Y3].

boeufs musqués répartis en 15 groupes. De plus, la structure de la population obtenue à partir d'observations terrestres a été établie à:

- 26 mâles adultes (3 ans et plus)
- 39 femelles adultes (3 ans et plus)
- 16 animaux de 2 ans
- 26 animaux de 1 an
- 38 veaux de quelques semaines

et 3 animaux non classables.

Ces observations permettent d'affirmer que le boeuf musqué au Nouveau-Québec, dans des secteurs actuellement peu utilisés par le caribou (*Rangifer tarandus*) est implanté et en pleine expansion.

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Reçu le 12 septembre 1983
Accepté le 28 juillet 1984

An Albinistic Yellow-spotted Salamander, *Ambystoma maculatum*, from Oak Bay, Quebec

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Lowcock, Leslie A. 1985. An albinistic Yellow-spotted Salamander, *Ambystoma maculatum*, from Oak Bay, Quebec. Canadian Field-Naturalist 99(1): 105–106.

An albinistic *Ambystoma maculatum* is recorded from Canada for the first time. It is the seventh report of albinism in this species.

Key Words: albino, Yellow-spotted Salamander, *Ambystoma maculatum*, first, Canada.

While conducting a spring survey of variation and distribution of mole salamanders in 1983, I observed thousands of individual Yellow-spotted Salamanders, *Ambystoma maculatum*, during their breeding period in early April and May in Nova Scotia, New Brunswick, Prince Edward Island, Maine and the Gaspé peninsula of Quebec. Although specimens possessing atypical spotting patterns were occasionally encountered, individuals lacking spots altogether (melanistic) were not. Only one with a markedly abnormal pigmentation was seen: an albinistic individual which was collected and is described here.

On the night of 10 May 1983, during a light rain (air = 1°C, water = 2°C), a migration of Yellow-spotted Salamanders was taking place from the surrounding countryside into a series of ditches beside a secondary road which runs parallel to the north side of route 132 approximately 2.5 km west of Oak Bay, Quebec (48°02′31″ N, 66°41′48″ W). At 2100 h, in a recently cleaned ditch which drained scrub and farmland perpendicular to the south side of the road, an albino individual was observed moving downstream (north) into the main roadside ditch. Approximately 20 *Ambystoma maculatum* were present in the vicinity of the albino; the majority were males.

Because this was a unique opportunity to study an aberrant member of a population during a breeding aggregation, an effort was made to observe both the behavior of the albino and that of conspecifics towards it. In addition, its conspicuously swollen vent area indicated it was a male and I hoped that it would deposit spermatophores which could be used in breeding experiments with normally pigmented females. However, this approach had to be abandoned after half an hour because the constant illumination of the water by our collecting lamps appeared to have an inhibitory effect on the activity of both male and female salamanders and, if these lights had been turned off, contact could have been lost with the albino male.

The albino was captured along with 10 other *A. maculatum* from this site and all were shipped live to the University of Guelph. Laboratory examination of the albino confirmed that it is a male, 75.3 mm SV length (measured tip of snout to the posterior margin of the vent) with a 3.95 mm internarial distance. Closer scrutiny of the specimen revealed that some melanophores are present in the integument (Figure 1). They occur randomly across the parotid area of the head (Figure 2) and the upper costal folds onto the dorsal surface proper. The melanophores are most concentrated on the dorsal midline where, although not forming an area of continuous pigmentation, they are visible to the unaided eye as a linear entity. The general color of the specimen is light pink (attributable to the underlying tissue) except for areas of concentrated fat deposition or glands such as the parotids and tail, which appear milky white. The eyes of the salamander appear red but the scleral coat is dark as in normal *Ambystoma*. Smith and Michener (1962) collected a similar specimen of *A. maculatum* in New York state with a normal scleral coat but in which the eyes reflected pink when viewed parallel to a light beam.

Although morphological abnormalities such as polydactyly or digital fusion are occasionally encountered in albinistic individuals (eg. Smith and Michener 1962) there are no obvious physical anomalies in this specimen. It remains in good health, maintained in the live collection at the University of Guelph. After morphometric, electrophoretic and anatomical comparisons with the rest of the animals collected from this site it will be deposited in the collection of the National Museum of Natural Sciences, National Museums of Canada, Ottawa.

Hensley (1959) summarized the known instances of albinism in the amphibians and reptiles of North America, Gilboa and Dowling (1974) provided a computerized bibliography of albinism in amphibians and reptiles from 1849–1972, and Dyrkacz (1981)

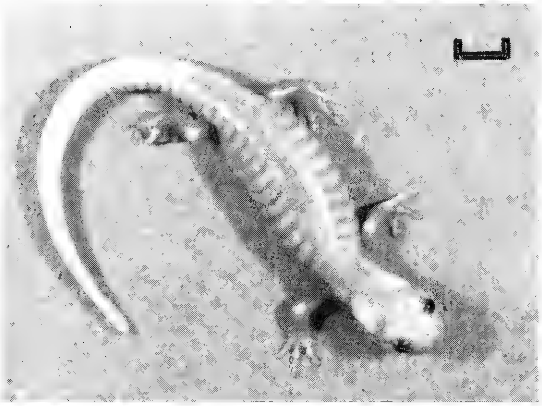

FIGURE 1. Albinistic male *Ambystoma maculatum*. Note scattered melanophores on mid-dorsal line. Scale represents 1 cm.

dealt with recorded occurrences since the time of Hensley's paper. While far from common, instances of albinism, to whatever degree, are more frequently recorded from *Ambystoma* than all other salamander genera combined. Hensley (1959) and Dyrkacz (1981) give six previous records for *A. maculatum* from New York (2), Maryland (2), Tennessee (1) and Kentucky (1).

Dyrkacz (1981) presented a convenient table linking description to terminology for degrees of albinism. However, the specimen described here does not readily fit Dyrkacz's criteria for complete albinism, partial albinism, albinistic pinto or the leucistic condition. Hensley (1959) defined demonstration of complete albinism as those animals that exhibit no apparent melanin in their body patterns and that possess a pink or red eye color. He also noted that "varying degrees of melanin concentrations are expected and definitions of albinism are largely ones of individual interpretation." In light of this statement and despite the scattered melanophores, the individual reported here appears to be the first record of an albinistic *Ambystoma* in Canada.

Acknowledgments

Field work was partially funded by an NSERC grant (A9866) to Dr. J.P. Bogart. I extend my thanks to Dr. Bogart for support and valuable advice concerning the manuscript and acknowledge the indispensability of my field assistant, Danny Jacques.

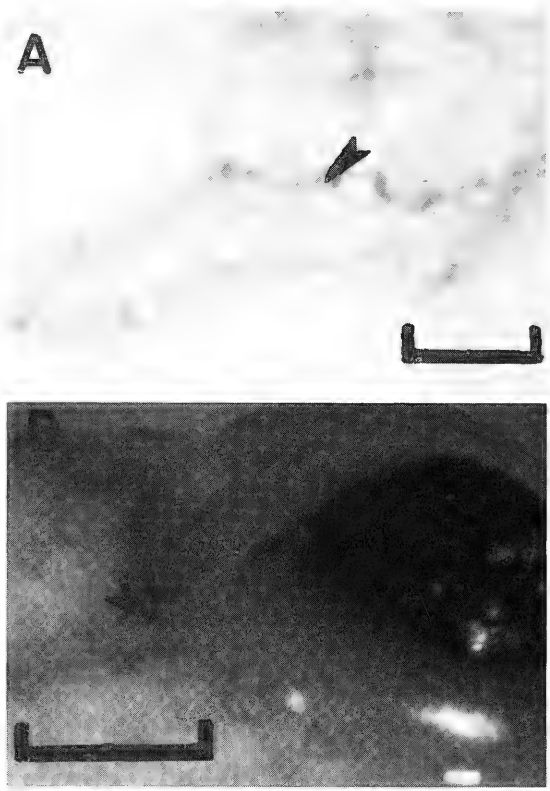

FIGURE 2. The sub-parotid canal (A) and the junction of this canal with the posterior angle of the eye (B). In both cases the arrows point to melanophores. Note the dark sclera coat of the eye. The scale in both photos represents 1 mm.

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Received 7 November 1983
Accepted 29 August 1984

Additional Records of the Brook Stickleback, *Culaea inconstans*, from Nova Scotia

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Gilhen, John, and Edward Claridge. 1985. Additional records of the Brook Stickleback, *Culaea inconstans*, from Nova Scotia. Canadian Field-Naturalist 99(1): 107–109.

Collections of Brook Stickleback, *Culaea inconstans*, in the River Philip, Shinimicas River and Tidnish River watersheds, Cumberland County, from 1970 to 1978, confirm that this species is native to Nova Scotia.

Key Words: Brook Stickleback, *Culaea inconstans*, distribution, Nova Scotia.

The stickleback family (Gasterosteidae) is represented in Nova Scotia by five species. The Blackspotted Stickleback, *Gasterosteus wheatlandi*, is a marine species found in certain estuaries along the Atlantic coast of this province. The Fourspine Stickleback, *Apeltes quadracus*, Threespine Stickleback, *Gasterosteus aculeatus* and Ninespine Stickleback, *Pungitius pungitius*, are three species which are found in both freshwater and marine habitats. To collections in three major watersheds in the Cumberland lowlands, all draining into the Northumberland Strait, we add with certainty the Brook Stickleback, *Culaea inconstans*, (Figure 1), a freshwater species.

The Brook Stickleback was first discovered in Nova Scotia in May 1970 (Gilhen 1970). At that time J. G. collected samples of small freshwater fishes in the Nappan River (which drains into the Bay of Fundy) and in River Philip. These fish were brought back to the Nova Scotia Museum alive for exhibit purposes and a single Brook Stickleback was found in the mixed sample. Three additional trips to both rivers were made without confirming the presence of Brook Sticklebacks at either location. Although Livingstone (1951) had predicted that Brook Sticklebacks might be discovered in Nova Scotia in future surveys, the possibility remained of accidental introduction during the exchange of salmonids at a fish culture station in the Williamsdale area of River Philip. Scott and Crossman (1973) included Nova Scotia on their distribution map for *Culaea inconstans* in Canada based on this problematic record from Cumberland County.

Garside and Chen (1974) confirmed that the Brook Stickleback inhabits the River Philip watershed on 5 September 1973 when three additional specimens were taken with a seine and dip net in the general area near Route 104, Oxford area, Cumberland County.

In the summers of 1976, 1977 and 1978 we observed that *Culaea inconstans, Gasterosteus aculeatus* and *Pungitius pungitius* were very common in silty bottomed, densely vegetated ponds in an old gravel pit adjacent to River Philip at Oxford Junction (Figure 2). In addition, all three were found to be common, in John Smith Brook and Ibbitson Brook (Figure 3), two tributaries of the Shinimicas River, and in Chapman Brook, a tributary of Tidnish River. These three streams are narrow, slow moving, meandering, silty bottomed and vegetated. We also noted that *Culaea inconstans* and *Pungitius pungitius* were common in cattail ponds near Little West Tidnish River at Route 366 and near Ibbitson Brook (Figure 4) at Route 6. All collections to date are summarized in Table 1.

In 1978 we collected fish in Meadow Brook, a tributary of Pugwash River, Cumberland County, but the only stickleback found was *Pungitius pungitius*. Pugwash River is directly east of River Philip and also drains into the Northumberland Strait.

In 1983 J. G. collected fishes in the headwaters of the LaPlanche River and in MacLellans Brook, a small tributary of the LaPlanche River, but the only sticklebacks found were *Gasterosteus aculeatus* and *Pungitius pungitius*. The LaPlanche River is directly southwest of the Tidnish River and, like the Nappan River, drains into the Bay of Fundy. The sections of these streams collected in were similar in habitat to those where *Culaea inconstans* were found. Therefore, in Nova Scotia the Brook Stickleback is probably confined to the River Philip, Shinimicas River and Tidnish River watersheds of the Cumberland lowlands (Figure 5).

These collections and observations are firm evidence that the Brook Stickleback is native to Nova Scotia. Livingstone (1951) admitted that during his survey of the freshwater fish of Nova Scotia he gave the least attention to Cumberland, Colchester and Pictou Counties and he probably did not collect in the narrow densely vegetated nursery tributaries where *Culaea inconstans* are most common. However, and as Garside and Chen (1974) pointed out, the fact that Brook Sticklebacks are found only in Cumberland County adds merit to Livingstone's hypothesis that the entire freshwater piscifauna invaded Nova Scotia across the Isthmus of Chignecto.

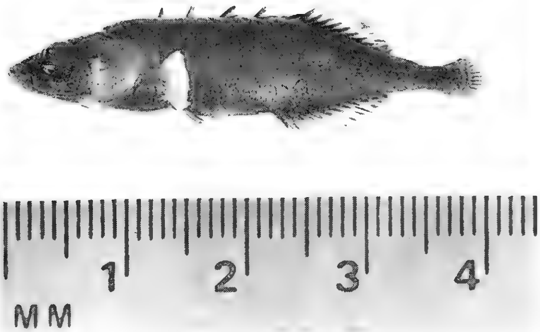

FIGURE 1. An adult male Brook Stickleback, *Culaea inconstans*, from Ibbitson Brook, Cumberland County, Nova Scotia (Photograph by R. E. Merrick).

FIGURE 2. A densely vegetated pond in an old gravel pit near River Philip at Oxford Junction, Cumberland County, Nova Scotia, habitat for the Brook Stickleback, *Culaea inconstans* (Photograph by R. E. Merrick).

FIGURE 3. Ibbitson Brook, Cumberland County, Nova Scotia, habitat for the Brook Stickleback, *Culaea inconstans* (Photograph by R. E. Merrick).

FIGURE 4. A cattail pond near Ibbitson Brook, Cumberland County, Nova Scotia, habitat for the Brook Stickleback, *Culaea inconstans* (Photograph by R. E. Merrick).

TABLE 1. Brook Stickleback, *Culaea inconstans*, collections from Cumberland County, Nova Scotia, in the Nova Scotia Museum ichthyology collections.

Cat. No.	No. Specimens	Locality	N. Lat. and W. Long.	Date	Collectors
970–134–1(1)	1	"River Philip" [by later restriction, see text]	45°43′01″, 63°52′00″	10 May 1970	J. Gilhen
974–4–1(1)	1	River Philip	45°41′05″, 63°53′00″	5 September 1974	E. T. Garside and L. A. Chen
978–133–1(37)	37	Near Little West Tidnish River	45°54′06″, 64°06′02″	17 July 1978	J. Gilhen and E. Claridge
978–134–1(16)	16	Ibbitson Brook	45°52′04″, 63°54′06″	17 July 1978	J. Gilhen and E. Claridge
978–145–1(9)	9	Near Ibbitson Brook	45°53′05″, 63°57′02″	5 August 1978	J. Gilhen and E. Claridge
978–148–1(9)	9	John Smith Brook	45°50′08″, 63°52′03″	8 August 1978	J. Gilhen and E. Claridge
978–149–1(5)	5	Chapman Brook	45°56′05″, 64°58′07″	9 August 1978	J. Gilhen and E. Claridge

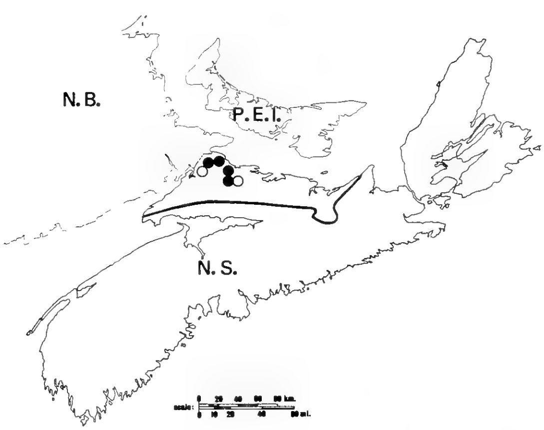

FIGURE 5. Distribution of the Brook Stickleback, *Culaea inconstans*, in Nova Scotia. Solid line represents the limits of the Cumberland lowlands. Closed circles represent localities where Brook Sticklebacks, *Culaea inconstans*, were found. Open circles represent localities where they were searched for but not found.

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Received 13 October 1983
Accepted 28 July 1984

Notes on the Occurrence and Ecology of the Black Bullhead, *Ictalurus melas*, near Creston, British Columbia

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Forbes, L S., and D. R. Flook. 1985. Notes on the occurrence and ecology of the Black Bullhead, *Ictalurus melas*, near Creston, British Columbia. Canadian Field-Naturalist 99(1): 110–111.

A large reproducing population of Black Bullheads (*Ictalurus melas*) was found in the Kootenay River system near Creston, British Columbia, in 1981. This record extends the known range of the species reliably recorded previously only from Osoyoos and Vaseux lakes in the Okanagan River system. Spawning of *I. melas* occurred later in 1981 than in 1982, perhaps due to a cool June. Seven species of piscivorous birds preyed and scavenged upon *I. melas*.

Key Words: Black Bullhead, *Ictalurus melas*, range extension, British Columbia, spawning, predation.

In 1981 we found a large reproducing population of Black Bullheads (*Ictalurus melas* Rafinesque) in the shallow lakes and marshes of the Kootenay River floodplain on the Creston Valley Wildlife Management Area (CVWMA) in southeastern British Columbia. In 1981 and 1982 we collected information on the distribution, breeding chronology, growth, diurnal activity and predation of Black Bullheads; the results are presented here.

Bullheads were captured with a beach seine, monofilament gill-nets, and dip nets. Lengths were measured with vernier calipers and a fish-measuring box, and weights were measured with hand-held spring balances. The bullheads were identified as *I. melas* as distinct from the Brown Bullhead (*I. nebulosus* Leseuer), the only other ictalurid in British Columbia, by the anterior configuration of the supraethmoid depression (Calovich and Branson 1964; Paloumpis 1964) and the size and strength of the posterior dentations of the pectoral spines (Paloumpis 1963).

Dymond (1936) and Carl (1945) believed that reports of *I. melas* from southwestern British Columbia were based on misidentification of *I. nebulosus*. The first confirmed record of *I. melas* in British Columbia was from a small pond adjoining Osoyoos Lake in the Okanagan system (Carl 1945). Carl et al. (1967) reported that Osoyoos Lake was the only location in British Columbia where *I. melas* was known to occur. More recently *I. melas* was collected from Vaseux Lake in the Okanagan system north of Osoyoos Lake (Fish Museum, Department of Zoology, University of British Columbia catalogue no. BC72–79). The indication of *I. melas'* presence in the Kootenay River system in British Columbia on Scott and Crossman's (1973: 592) range map was apparently the result of a mapping error (E. J. Crossman, personal communication). Northcote (1973) reported a single moribund *I. melas* from Kootenay Lake in 1968, however, and speculated that it was discarded live-bait used by anglers. We found *I. melas* in large numbers in 1981 and 1982 in Corn Creek Marsh, Duck Lake, Leach Lake, the marshy southern edge of Kootenay Lake near Kootenay Landing, and Six-mile Slough. Ictalurid fry were found in Duck Lake as early as 1971 (D. D. Moore, personal communication) and have been taken in Corn Creek Marsh each year since 1975 (K. Haskell, personal communication). *I. melas* is present upstream in the Kootenay River drainage in Montana (Brown 1971) and downstream in the Columbia system in Washington and Idaho (Gray and Dauble 1977; Simpson and Wallace 1978), therefore *I. melas* may have dispersed to the Creston area from either direction. We cannot however exclude the possibility of human introduction.

Spawning activity and schools of fry of ictalurids, presumably *I. melas*, were observed in Duck Lake, Corn Creek Marsh, and the marshy edge of Kootenay Lake near Kootenay Landing, and spawning probably occurred in other shallow waters of the CVWMA as well. Bullheads were most closely monitored in Corn Creek Marsh. In 1981 the earliest schools of *I. melas* fry were observed on 8 August. In 1982, spawned-out *I. melas* were first captured there in early June, and schools of fry were first observed on 29 June. A cool June in 1981 (Table 1) perhaps delayed spawning that year. Spawning was approximately synchronous among those water bodies in 1982.

The growth of *I. melas* fry was monitored in Corn Creek Marsh. In 1982 a mean total length of 34.8 mm (Table 2) was attained by 11 August, whereas in 1981 the mean total length on 21 August was only 23.3 mm (S.D. = 1.05, n = 80). Adults ranged up to 570 g and 280 mm total length in Duck Lake. The functional relationship between weight and length for bullheads

TABLE 1. Mean spring temperature (°C) at Creston in 1981 and 1982[1]

		April	May	June
1982		6.6	11.8	18.1
1981		8.1	12.6	13.7
1971–1980	$\bar{x}$	8.0	12.7	16.0
	S.D.	1.3	1.3	1.5

[1]Atmospheric Environment Service, Environment Canada, unpublished data.

TABLE 2. Growth of *Ictalurus melas* fry at Corn Creek Marsh in 1982

Date	Mean Total Length (mm)	S.D.	n
29 June	20.3	2.8	39
5 July	22.3	4.2	120
30 July	24.9	5.2	40
11 August	34.8	3.7	33

from the CVWMA, as estimated by the geometric mean regression, is:

$$\text{Log } w = -5.27 + 3.289(\log l) \quad (n = 500)$$

I. melas populations in the relatively clear (Secchi disc > 220 cm) Duck Lake were active only at night judging from relative catches in daytime and overnight gill-net sets. There *I. melas* were rarely taken in daytime sets, but were abundant in overnight sets. *I. melas* were taken abundantly in both daytime and overnight gill-net sets in the more turbid Corn Creek Marsh (Secchi disc > 95–100 cm) which suggests that the species was both diurnally and nocturnally active there.

Scott and Crossman (1973) noted that predation on *I. melas* was apparently very low. At Creston, however, we observed Red-necked Grebe (*Podiceps grisegena*), Pied-billed Grebe (*Podilymbus podiceps*), Great Blue Heron (*Ardea herodias*), Common Merganser (*Mergus merganser*), and Osprey (*Pandion haliaetus*) prey upon *I. melas*. At Corn Creek Marsh *I. melas* was the primary prey species of Osprey (Flook and Forbes 1983) and Great Blue Heron (Forbes and Flook unpublished data). Ring-billed Gull (*Larus delawarensis*) and Bald Eagle (*Haliaeetus leucocephalus*) scavenged *I. melas* carcasses.

Specimens of *I. melas* from the CVWMA have been deposited in the Royal Ontario Museum [Catalogue number (accession) 4595].

Acknowledgments

These observations were made in conjunction with a Canadian Wildlife Service study of the population ecology of piscivorous birds on the CVWMA. D. D. Moore, B. G. Stushnoff and R. W. Butler provided logistical support and advice. B.-A. Chapman assisted with the fish sampling. E. J. Crossman kindly provided information on the range of *I. melas* in British Columbia and on the identification of the species. E. Holm confirmed our identification of *I. melas*. E. J. Crossman, N. J. Wilimovsky and R. W. Butler reviewed the manuscript. We thank them all.

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Received 27 October 1983
Accepted 28 July 1984

Probable Case of Mercury Poisoning in a Wild Otter, *Lutra canadensis*, in Northwestern Ontario

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Wren, Christopher D. 1985. Probable case of mercury poisoning in a wild Otter, *Lutra canadensis*, in northwestern Ontario. Canadian Field-Naturalist 99(1): 112–114.

A wild Otter (*Lutra canadensis*) was found dead on the ice of mercury-contaminated Clay Lake, near Dryden, Ontario. Tracks in the snow indicated that the animal behaved strangely prior to death, and subsequent tissue analysis revealed extremely high levels of mercury. These observations strongly suggest that the Otter died of mercury poisoning. Mercury levels in fish from the Wabigoon-English River system remain at concentrations which are toxic to furbearers such as Mink (*Mustela vison*) and Otter.

Key Words: Mink, Otter, *Lutra canadensis*, mercury, fish, behavior, toxic.

The Wabigoon-English River system in northwestern Ontario is recognized as being one of the most mercury-contaminated waterways in Canada (Armstrong and Hamilton 1973). The source of the mercury was a chlor-alkali plant in Dryden, Ontario, which released over 10 000 kg of mercury into the Wabigoon River between 1962 and 1970. The discharge of mercury was substantially reduced between 1970 and 1975, and ceased altogether in October, 1975, when the plant was converted to a process that does not use mercury.

The discharge of mercury into the Wabigoon River resulted in extremely elevated mercury levels in fish living downstream of Dryden. Fimreite and Reynolds (1973) reported that mercury levels in fish collected in 1970 were elevated as far as Tetu Lake, 320 km downstream of Dryden, but were highest in fish from Clay Lake, about 80 km downstream from Dryden. For example, the mean mercury level in muscle tissue of Walleye (*Stizostedion vitreum vitreum*) from Clay Lake was 15.7 $\mu g/g$, wet weight (parts per million) compared with 0.7 $\mu g/g$ in similar size Walleye from a nearby, but uncontaminated lake (Fimreite and Reynolds 1973). The recommended "safe" level of mercury in fish for human consumption is 0.5 $\mu g/g$ in Canada, and 1.0 $\mu g/g$ in Sweden, Japan, and the USA.

The possible toxicological effects in wildlife consuming mercury-laden fish from this river system have not been investigated. However, consumers are likely to be affected, as Takeuchi et al. (1977) diagnosed methylmercury poisoning in cats living on an Indian Reserve along the English River. The cats were fed a diet consisting of table scraps and fish from the English River. Fimreite and Reynolds (1973) reported that an Indian trapper had discontinued trapping in the Clay Lake area because furbearers such as Mink (*Mustela vison*) and Otter (*Lutra canadensis*) had disappeared in recent years.

In February, 1979, a trapper followed an erratic set of Otter tracks along Clay Lake and eventually found the animal dead (R. Robinson, personal communication). The tracks indicated that the Otter had behaved abnormally before dying: travelling in circles, falling over and burrowing into the snow. An eagle (*Haliaeetus leucocephalus*) was starting to scavenge the carcass when the trapper appeared. This trapper reported that he had found other dead Otters as well as dead Mink within the area of his trapline, while another local trapper had also observed tracks of wild Otters travelling in unusual circular patterns.

The carcass was submitted to the Ministry of Natural Resources in Dryden for mercury analysis, which was subsequently conducted by the Ontario Ministry of the Environment, Rexdale. Total mercury levels in the Otter tissue were measured by cold vapour atomic absorption as outlined by Environment Canada (1981). The sensitivity of the technique at the Ontario Ministry of the Environment is set at 0.01 $\mu g/g$ (ppm) with a precision of $\pm$ 10% on five or more replicates.

Tissue mercury levels in the Otter found dead on Clay Lake were extremely elevated relative to apparently healthy animals trapped in other areas (Table 1). For example, mercury concentrations in liver and kidneys of the Clay Lake Otter were 96.0 and 58.0 $\mu g/g$, respectively, compared with 3.0 and 1.4 $\mu g/g$, respectively, in Otters from an unpolluted watershed near Parry Sound, Ontario (Wren et al. 1980). Tissue mercury levels in the Clay Lake Otter were also substantially higher than terminal mercury levels in Otters experimentally killed by feeding methylmercury in their diet (Table 1).

In a laboratory experiment, O'Connor and Nielsen (1980) demonstrated that a methylmercury concentra-

TABLE 1. Comparison of mean total mercury concentrations ($\mu g/g$ wet weight) reported in mercury-poisoned, and healthy, wild Otters.

Location/Comments	N	Tissue: Liver	Kidney	Muscle	Brain	Reference
Mercury-poisoned						
Clay Lake, Ontario, found dead	1	96.0	58.0	36.0	30.0	this report
Experimentally killed by methylmercury in food	9	33.4	39.2	15.7	18.9	O'Connor and Nielsen 1980
Normal						
Northeastern USA						
males	14	4.3*				" "
females	15	2.2*				" "
South-central Ontario	4	3.0	1.4	0.9		Wren et al 1980
Louisiana	100	1.3				Beck 1977
Georgia						
Ware County	6	9.1		4.6		Halbrook 1978
Echols County	4	5.1		4.2		Halbrook 1978
Wisconsin	49	3.3	8.5	1.4	0.7	Sheffy and St. Amant 1982

*Converted from methylmercury concentrations reported in original paper, assuming that methylmercury represents 50% of total mercury in Otter liver.

tion as low as 2.0 $\mu g/g$ in the diet was lethal to Otters within 184 days, 4.0 $\mu g/g$ was lethal within about 117 days, and 8.0 $\mu g/g$ was lethal within 54 days. Although the release of mercury into the Wabigoon River was halted in 1970, there is still mercury in the river sediments, and fish mercury levels are also still elevated. In 1978, the average mercury concentration in Walleye from Clay Lake, at a standard 50 cm length, was 8.2 $\mu g/g$, and was 4.6 $\mu g/g$ in Northern Pike (*Esox lucius*) 60 cm in length (OME 1980). Experimental evidence suggest that these mercury levels are toxic to Otters and Mink (Wobeser et al. 1976; O'Connor and Nielsen 1980).

The erratic behavior of the Clay Lake Otter prior to death, as indicated by tracks in the snow, is consistent with clinical observations made on animals suffering from methylmercury poisoning. Falling and walking in circles has been cited as a clinical symptom of methylmercury intoxication in Ferrets (*Mustela putorius*) and Mink (Hanko et al. 1970; Wobeser et al. 1976). A wild Mink found near the mercury-contaminated Saskatchewan River was observed travelling in circles, rolling over and attempting to burrow into the snow immediately prior to death (Wobeser and Swift 1976). Subsequent tissue analysis and pathological examination indicated that the animal died from methylmercury poisoning. Wobeser et al. (1976) suggest that mercury concentrations greater than 5.0 $\mu g/g$ in brain and muscle tissue, in association with appropriate clinical and pathological findings, could be used as criteria for diagnosis of mercury intoxication. The level of mercury in brain tissue of the Clay Lake Otter was 30.0 $\mu g/g$.

The sighting of an eagle perched on the Otter is a significant observation as it emphasizes a number of important facts. First, it illustrates the rapidity with which sick or dead animals are preyed upon in the wild. This greatly reduces the chance of finding carcasses of wild animals affected by environmental contaminants. The fact that several animals were found dead within this area suggests that relatively large numbers of animals may have been affected by a common disease or toxic substance. Secondly, it emphasizes that the chance of survival are greatly reduced in an animal whose behavior is modified by a contaminant that renders it more susceptible to predation. Sublethal effects of a toxic substance, such as impaired reproduction or abnormal behavior, are extremely difficult to measure in wild animals, but can have a significant effect on animal populations. Thirdly, this observation places the Otter within an ecological framework in which accumulated body burdens of a toxic substance can be rapidly and efficiently transferred from one level of the food chain to the next.

The unnatural behavior of the Clay Lake Otter prior to death, coupled with the extremely high tissue mercury levels strongly suggest that this animal died of mercury poisoning. Recent declines in Otter populations in other countries have largely been attributed to environmental pollution (Erlinge 1972; Chanin and Jefferies 1978; Green and Green 1981; Macdonald and

Mason 1982). Mercury is only one of a number of environmental contaminants including other toxic metals, pesticides, PCB's, organochlorines and radioactive materials, which can affect wildlife. In addition to playing an integral role in natural ecosystems, furbearers such as Mink and Otter are an economically valuable resource. The potential impact of toxic substances on these organisms remains to be examined.

Acknowledgments

The help and cooperation of staff at the Ministry of Natural Resources and D. Russell, Ministry of the Environment, is gratefully recognized. I also wish to thank Mr. R. Robinson for his acute observations, and foresight in submitting the dead Otter for mercury analysis.

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Received 18 November 1983
Accepted 27 August 1984

Longevity Record for a Wild Raccoon, *Procyon lotor*, in Manitoba

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Ducks Unlimited Canada, 1190 Waverley Street, Winnipeg, Manitoba R3T 2E2.

Cowan, Wayne F. 1985. Longevity record for a wild Raccoon, *Procyon lotor*, in Manitoba. Canadian Field-Naturalist 99(1): 115.

A female Raccoon trapped near Minnedosa, Manitoba had been fitted with a radio transmitter over 10 years earlier and was estimated to be 11 years, 7 months old. This is a record age for wild raccoons in Manitoba and only a year younger than the oldest documented previous record.

Key Words: wild, Raccoon, *Procyon lotor*, Manitoba, longevity.

A female Raccoon, *Procyon lotor*, was trapped on 12 December 1982 in pothole habitat near Minnedosa at 99°43′W longitude, 50°12′N latitude. This location was 2.5 km from where it was originally ear-tagged and fitted with a radio transmitter on 28 May 1972. The transmitter bore the number "8" carved 2 mm deep into an acrylic coating. It was not operating and the ear tags were missing.

Terry Hershey, U.S. National Forest Service (Orfino, Idaho), who had released the animal while on a M.Sc. field research program, positively identified it by means of a numbered transmitter. It was a yearling when released in May 1972, and as May is the mean month of birth for Raccoons in the Minnedosa area (Cowan 1973), the probable age when trapped was 11 years, 7 months. It was in healthy condition and likely could have survived that winter and longer.

Wild raccoons in North America have been estimated to live to be as old as 16 years (Johnson 1970). However, the greatest measured age was 12 years, 7 months. This was from the Swan Creek Wildlife Experiment Station, Allegan, Michigan (Haugen 1954).

The oldest recorded captive Raccoon was 17 years, 1 month, at Mound City, Illinois (Garrett and Goertz 1975). For Manitoba, a captive female taken as a whelp from a den at Delta in May 1969 was still surviving in August 1984. It was then 15 years, 3 months old (P. Ould, Ducks Unlimited Canada, Stonewall, Manitoba, personal communication).

Few published records of longevity in Raccoons exist. Determination of age in large specimens is very difficult beyond the yearling stage and since the large majority of formal studies are of only a few years duration, the opportunities to trace long-lived Raccoons are rare. Regional records are valuable to the determination of population structures and crucial management decisions for the control of local harvests and populations.

Acknowledgments

I thank Terry Hershey for identifying the radio transmitter and commenting on the Raccoon's probable age at capture. Albert Kruger, landowner, and Benny Nagorski, trapper, provided the transmitter and information concerning retrieval of the animal. Jeff Nelson, Ducks Unlimited Canada, critically reviewed the manuscript.

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Received 24 October 1983
Accepted 23 August 1984

The Tripletail, *Lobotes surinamensis*, New to the Fish Fauna of the Atlantic Coast of Nova Scotia and Canada

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Gilhen, John, and Don E. McAllister. 1985. The Tripletail, *Lobotes surinamensis*, new to the fish fauna of the Atlantic coast of Nova Scotia and Canada. Canadian Field-Naturalist 99(1): 116–118.

A specimen of the Tripletail, *Lobotes surinamensis* was caught at Sloughenwhite Ledge, St. Margarets Bay, Halifax County, Nova Scotia (44°37′N, 64°03′W) in August 1983. This specimen is the first record of the species and of the family Lobotidae for Nova Scotia and for Canada. It extends the known range northwards over 500 km. No significant differences were found between the specimen and published descriptions.

Key Words: Tripletail, *Lobotes surinamensis*, new record, Nova Scotia.

A Tripletail, *Lobotes surinamensis*, was caught in a mackerel trap at Sloughenwhite Ledge, St. Margarets Bay, Halifax County, Nova Scotia (44°37′N, 64°03′W) by Donald Harnish in August 1983. This specimen provides the first known record of this species and the family Lobotidae for Nova Scotia and Canada, and extends the known range over 500 km north from Cape Cod, Massachussetts.

We document this range extension here and provide a detailed description and additional information in the format of *Fishes of the Atlantic coast of Canada* by Leim and Scott (1966). Supplementary information was drawn from Böhlke and Chaplin (1968) and Hardy (1978). The French vernacular was obtained from Smith (1981).

Family LOBOTIDAE Tripletails

This family is comprised of the Tripletail, *Lobotes surinamensis*, found world-wide in warm waters, and one other genus, *Datnioides*, with several species in brackish and fresh waters of the East Indies. These fishes resemble the Serranidae (Basses: see Leim and Scott 1966: 234–242) but lack vomerine and palatine teeth, and a subocular shelf, typical of that family. The name Tripletail comes from the posterior position of the dorsal and anal fins which give the impression of a three-lobed tail.

Tripletail **Croupia roche**
Lobotes surinamensis (Bloch, 1790)

DESCRIPTION: Body short and deep, its maximum depth 2.5 times in total length (TL), 2.1 times in standard length (SL), compressed, caudal peduncle deep, 6.3 times in SL. Head profile concave, length entering 3.5 times in TL, 2.8 in SL; two flat spines on operculum; both arms of preoperculum serrate with backward projecting lobe at angle; mouth superior, short, ending below mid-pupil; upper jaw 2.9 in HL, lower jaw protruding before upper; small rows of conical teeth on jaws; vomer and palatines toothless. Orbit entering 7.9 times in HL. Fins: dorsal (1), XII, 15, strong dorsal spines increasing in height to the 5th which enters 2.6 times in HL, then decreases to soft dorsal fin rays which in turn increase to maximum height in posterior third then rapidly diminish forming a point; caudal rounded; anal III, 11, spines strong, third the longest, entering 4 times in HL, soft rays forming a rounded point; pectorals rounded, length 2.1 in HL; pelvics pointed, longer than pectorals, 1.5 times in HL. Lateral line distinct with 47 scales, following curvature of dorsal profile then descending to mid-lateral position on caudal peduncle. Gill rakers moderately long, 2/3 of orbit diameter, 6+14=20 (5+14=19 on right side). Large scales, weakly ctenoid, covering body, opercular bones, cheek, and top of head forwards almost to the nostrils. Vertebral centra 24, with 11 abdominal and 13 caudal centra including the urostylar centrum. (Description based on Canadian specimen).

COLOR: In our preserved specimen, body and fins, (except for the almost transparent pectoral fins), dark chocolate brown, with the centers of the scales darker, and the lighter belly. Distal edge of the caudal fin without pigment. When fresh, the scales were mottled dark purplish-brown and bluish-green, slightly darker above and with the posterior margin of caudal fin white. Other specimens have been reported to be pale brown, greenish, and cream yellow. Juveniles have spots at the bases of the soft dorsal and anal fins.

DISTINCTIONS: The dished-out forehead, deep body, single spinous and soft-rayed dorsal fin of the Tripletail resemble the Spotfin Butterflyfish [*Chaetodon ocellatus*, see Leim and Scott 1968: 265–267] but is unlikely to be confused with any other fish of the region. The Tripletail differs from the Spotfin Butter-

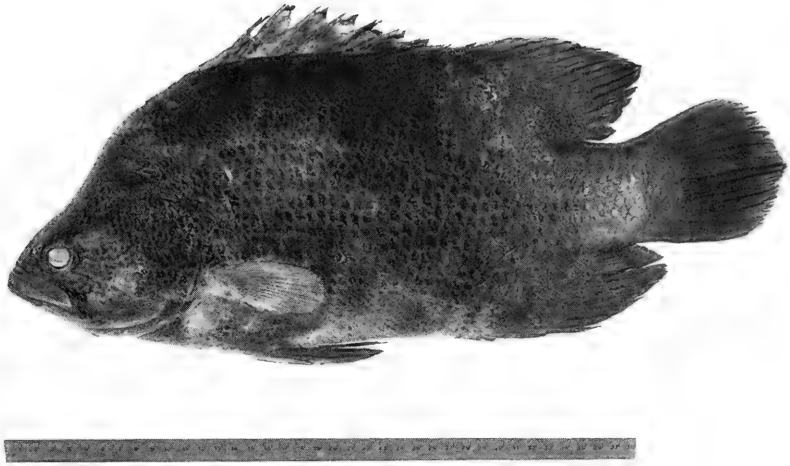

FIGURE 1. Photograph of 366 mm SL specimen of Tripletail, *Lobotes surinamensis*, caught at Sloughenwhite Ledge, St. Margarets Bay, Halifax County, Nova Scotia.

flyfish in the lack of a dark band through the eye and the head, the pelvic fins not reaching the anal fin, and the soft dorsal rays forming a point instead of a rounded curve.

SIZE: Attains a length of 1016 mm (Böhlke and Chaplin 1968), common to 500 mm (Smith 1981). Our specimen was 450 mm in TL, 366 mm in SL, and weighed 1.92 kg.

RANGE: Recorded from warm seas around the world. In the western Atlantic, known from Argentina to Bermuda, and was previously known north to Cape Cod, Massachussetts. In the eastern Atlantic, occurs on the west coast of Africa, the Mediterranean, and St. Helena; in the Indo-Pacific from Iran and Korea to southern Australia; in the eastern Pacific from Panama and Mexico where it was known as *Lobotes pacificus* Gilbert.

Canadian distribution: Known only from Sloughenwhite Ledge, St. Margarets Bay, Halifax County, Nova Scotia (44° 37′N, 64° 03′W), where it was caught by Donald Harnish in August 1983 (National Museum of Natural Sciences catalogue number NMC83-0746).

BIOLOGY AND ECONOMICS: Spawns from July to August in the United States. Mature eggs probably exceed 1 mm in diameter. Very small specimens dwell inshore amongst algae in brackish water. Juveniles up to 330 mm float at the surface, often under clumps of floating sargassum weed, but sometimes on their sides mimicking mangrove leaves. Young float great distances in sargassum weed and have been seen in schools some distance offshore, apparently migrating. Adults live in coastal areas around man-made structures, in bays, harbours, passes, rivers, and at mouths of small freshwater streams, over bottoms of sand, rock or coral. Often lie on sides at the surface. Usually between 1–40 m depth, and usually inshore of 275 km. In South Carolina they move inshore in spring through fall.

Acknowledgments

Donald Harnish captured this specimen and drew it to our attention. Judy L. Camus took the radiograph used for vertebral counts. We would like to thank both these persons for their valuable assistance.

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Received 21 December 1983
Accepted 31 July 1984

News and Comment

Final Announcement: XIX Congressus Internationalis Ornithologicus

The 19th International Ornithological Congress will be held in Ottawa, Canada, from 22 to 29 June 1986. Its President is Prof. Dr. Klaus Immelmann. The scientific programme has been determined and comprises plenary lectures, symposia, contributed papers (oral and posters), round table discussions, special interest group meetings, and workshops. Pre and post-congress excursions and workshops are planned, as well as early morning bird walks and other activities for members and accompanying members.

The deadline for registration and submission of contributed papers is January 1986. Additional information, the final circular and registration forms are available from:

Dr. Henri Ouellet

Secretary General
XIX Congressus Internationalis Ornithologicus
National Museum of Natural Sciences
Ottawa, Ontario, Canada
K1A 0M8

New Herpetological Appointments at Canadian Museums

The Royal Ontario Museum, Toronto, Department of Ichthyology and Herpetology, has announced the October 1984 appointment of Dr. Bob Murphy as Assistant Curator (Herpetology), its first curatorial appointment in herpetology since the late E. B. Shelley Logier retired in 1961. Dr. Murphy obtained his Ph. D. from the University of California at Los Angeles in 1982 and his research has concentrated on the systematics and evolution of the Baja California herpetofauna. In the near future he hopes to initiate co-operative efforts with colleagues in China, and will be responsible for the planning and implementation of a major new permanent public gallery of amphibians and reptiles at the ROM. Dr. Murphy's over 30 published papers include work on southeastern skinks, Indonesian seasnakes, and rattlesnakes. Ross MacCulloch continues as Curatorial Assistant in herpetology and Jim Lovisek (Toronto) and Dr. James D. Bogart (University of Guelph) are Research Associates.

The National Museum of Natural Sciences, Ottawa, National Museums of Canada, announces the addition of Dr. David M. Green as a Research Associate to its Herpetology Section. Dr. Green is at McMaster University and is continuing his work on the evolutionary relationships of toads and of western brown frogs. His book *The Amphibians of British Columbia*, coauthered with R. Wayne Campbell, has recently been published by the British Columbia Provincial Museum. Dr. Green augments a herpetology research team which includes one other Research Associate, Dr. Frederick W. Schueler who is currently working on the herpetofauna of the Tobermory Islands, Georgian Bay, and the adjacent mainland; status reports on the Eastern Hognose Snake and Butler's Garter Snake in Ontario; and a book, *Fragile Inheritance* (with Aleta Karstad Schueler) on endangered ecosystems in Canada. Premanent staff are Mike Rankin, Curatorial Assistant, and Francis R. Cook, Curator. The latter's major project is a comprehensive reference text, *The Natural History of the Amphibians and Reptiles of Canada* scheduled for completion in 1990.

Francis R. Cook

New Publication Announcement: *The Herpetoculturalist*

The Reptile Breeding Foundation has announced a new publication, *The Herpetoculturalist*. This journal will deal with news and information on the propogation, maintenance, and husbandry of amphibians and reptiles as well as with education and conservation projects focused on these animals. Initial response from the herpetological community world-wide indicates that a quarterly journal dealing with these topics will receive extensive support. An inaugral issue, scheduled for early 1985, will deal primarily with the activities of the Foundation and will be distributed free on request.

The Reptile Breeding Foundation is a privately-funded, non-profit organization, established in 1975, which has achieved recognized success in captive breeding of endangered species. Its aims are to promote maintenance of genetic stocks from areas where increasing habitat degredation may make survival of natural populations impossible; to provide an alternative source of exhibit animals and thereby reduce legal and illegal pressures on currently still viable, but exploited, natural populations; and to hold a resevoir of breeding animals until local habitat enhancement will allow the potential for restocking success.

For further information on *The Herpetoculturalist* or the Foundation contact:

THOMAS A. HUFF, Director
The Reptile Breeding Foundation
P.O. Box 1450
Picton, Ontario K0K 2T0

Book Reviews

Zoology

Les noms français des oiseaux d'Amérique du Nord

Par Henri Ouellet et Michel Gosselin. 1983. Syllogeus no. 43. Musée national des sciences naturelles, Musées nationaux du Canada. Ottawa. 36 pp.

Cet ouvrage reproduit intégralement les noms scientifiques et américains des espèces d'oiseaux contenues dans le 34e supplément de la *Check-list of North American Birds* publié par *l'American Ornithologists' Union* en 1982 et il fournit un nom français pour chacune des espèces qui y sont énumérées. Dans une présentation sobre, le texte bien dégagé est d'une lecture aisée; l'impression est nette et les fautes typographiques semblent être inexistantes.

L'intérêt de cet ouvrage, comme son titre l'annonce, tient aux noms français donnés aux oiseaux. En effet, plusieurs des noms établis par Ouellet et Gosselin sont différents des noms utilisés dans les publications ornithologiques canadiennes récentes; ces derniers avaient été proposés par un comité de la Société zoologique de Québec et publiés d'abord en 1957 dans une brochure éditée par le Service canadien de la faune.

Les noms français retenus par Ouellet et Gosselin diffèrent surtout de ceux de la Société zoologique de Québec au niveau des désignations génériques; ces choix reflètent le souci de "corriger certaines erreurs ... qui ont toujours contribué à entretenir une profonde incertitude quant à l'identité de nos oiseaux." Ainsi tantale remplace cigogne, urubu remplace vautour, balbuzard remplace aigle pêcheur, pingouin remplace gode, paruline remplace fauvette, bruant remplace pinson, quiscale remplace mainate. Et ce n'est pas tout. Certains hérons sont maintenant des aigrettes, une sterne est appelée guifette, une maubèche devient un chevalier tandis qu'un chevalier devient un bécasseau, des moucherolles deviennent des tyrans, etc. Toujours avec le souci d'éliminer "les imprécisions et les erreurs", Ouellet et Gosselin ont également modifié la désignation spécifique du nom de diverses espèces. Par exemple, Bécasseau d'Alaska remplace Bécasseau du "Nord-Ouest" et Hirondelle noire remplace Hirondelle "pourprée". En outre, ils emploient "le nom utilisé en Europe francophone" pour désigner une espèce holarctique (Bécasseau violet, Jaseur boréal, Sizerin flammé), à moins que le nom en usage au Canada ne "soit supérieur ou profondément ancré dans la tradition."

Que faut-il penser de tout cela? Après avoir surmonté l'hésitation créée par le choc de la nouveauté et mis de côté la résistance au changement, il faut convenir de la justesse des désignations retenues par Ouellet et Gosselin. Il est vrai que les mainates sont des oiseaux asiatiques et que les oiseaux américains à qui on avait donné ce nom sont des quiscales, comme l'attestent tous les dictionnaires. La même chose peut être dite de presque tous les "nouveaux" noms présentés dans cet ouvrage: ils figuraient dans les dictionnaires avant que les noms qu'ils remplacent n'apparaissent dans les publications ornithologiques canadiennes. Le nom paruline, qui sert à désigner les oiseaux de la sous-famille Parulinae, différents des fauvettes de l'Ancien-Monde, est évidemment un néologisme de formation savante, comme le fut sturnelle en 1957 pour désigner les oiseaux du genre *Sturnella*, autrefois appelés étourneau abusivement. Il faut donc reconnaître que Ouellet et Gosselin ont atteint leur but: des oiseaux distincts ont des noms différents.

On peut cependant faire remarquer que les butors du genre *Ixobrychus* sont appelés blongios et que le congénère paléarctique du geai *Perisoreus* est connu comme un mésangeai; toutefois, ces noms entretiennent des rapports de synonymie, ce qui est loin d'être le cas de bruant et pinson par exemple. On peut cependant relever quelques faiblesses dans certaines modifications aux désignations spécifiques. Ainsi Mouette à tête noire (*Larus atricilla*) est moins exclusif que Mouette rieuse d'Amérique, bien que l'on comprenne que ce nom laisse supposer une parenté trop étroite avec la Mouette rieuse (*Larus ridibundus*). Par ailleurs, si on remplace Chouette cendrée par Chouette lapone (*Strix nebulosa*), on ne voit pas pourquoi Grèbe esclavon (*Podiceps auritus*) ne remplacerait pas Grèbe cornu.

En dépit de ces réserves mineures, cet ouvrage constitue une référence très valable. La révision en profondeur qu'il apporte à la nomenclature française des oiseaux canadiens employée jusqu'à maintenant démontre jusqu'à quel point cette dernière était déficiente, surtout en ce qui a trait aux désignations génériques. Cela même doit inciter à la réflexion. Malgré une difficulté d'adaptation passagère, la nomenclature française établie par Ouellet et Gosselin mérite d'être diffusée par les personnes, organismes et groupes qui publient des ouvrages sur les oiseaux, qu'ils soient spécialisés ou vulgarisés. Dans ces domaines, il ne faut pas oublier que la responsabilité première des auteurs est de diffuser des connaissances exactes. Même si bien des gens croient que les hiboux voient moins bien le jour que la nuit, les biologistes ne s'interdisent pas de dire le contraire afin de ne pas

déranger les convictions erronées du public; de la même façon les biologistes ont le devoir de ne pas continuer à dire qu'il y a des mainates et des fauvettes en Amérique. Quand on s'adresse au grand public, employer le terme qui révèle l'identité véritable des oiseaux constitue la diffusion d'une connaissance aussi importante que l'explication de n'importe quelle particularité anatomique ou éthologique.

NORMAND DAVID

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The Birds of Africa, Volume I

By Leslie H. Brown, Emil K. Urban, and Kenneth Newman. 1982. Academic Press. London. xii + 521 pp. illus. U. S. $109.

The need for a comprehensive handbook on the birds of Africa has existed for a long time. The late Leslie H. Brown planned to write *the* book, and in time involved Emil K. Urban and Kenneth Newman in this herculean task. They projected a four volume set to include the *ca* 1850 species of birds of the African continent, but Brown died before Volume I was published. (Volumes II-IV will be written by a number of contributors).

While the sheer size and weight of the book may, at first glance, put it in the category of coffee-table books, a quick perusal will assure any naturalist that this is not the case. *Birds of Africa* provides information which in the past had been dispersed in a wide variety of sources (e.g. regional guides, scientific journals, unpublished notes). Most of it is up-to-date. This information, combined with numerous line drawings and 32 plates (28 in colour) make it an important aid to anyone seriously interested in the birds of Africa.

A valuable feature of this volume is the lengthy (31 page) "Introduction." Divided into three parts it starts with "African Bird Faunas." Further sub-divisions consider the geological past, climate, vegetation, noteworthy bird habitats in Africa, the kind and numbers of birds in Africa, and movements of birds (e.g. Palearctic migration, intra-African migration and irregular movements). The next part discusses "Some possibilities for research," and is aimed at both resident and non-resident ornithologists. This will prove an indispensable aid to anyone contemplating work on African birds. The authors outline ten important but neglected areas of research. These are: collecting, systematics and distribution; nests and eggs; breeding seasons; voice and songs; daily routine and energy budgets; food and feeding methods; ringing, marking and migration studies; numbers and census data; pesticides and their effects . . .; and longer term studies. The authors stress the need for ecological and behavioural studies but do not neglect the need to deal with knotty problems of taxonomy. Moreover they emphasize the need to study the living bird, because in the past most work on African birds was based on museum specimens.

These last points are reiterated in part three of the "Introduction" under the heading of "Scope, Content and Layout of Text." Content and layout comprise range and status, description, field characters, voice, general habits, food, and breeding habits (when known). Three maps, on the topography, vegetation and political divisions of Africa are also part of this important "Introduction" and several figures and tables are also included. Finally there are two pages of drawings, illustrating the external parts of birds.

The major part of the book deals with ten orders of birds from Struthioniformes to Falconiformes. A range map is included with each species account. References are given at the end of each account, a very useful feature in my opinion. Name headings are in bold-face type and begin with the scientific name of the species followed by both English and French names. Another interesting and useful feature is that references to the original description and specimen are also given. Cross-referencing between species accounts and plates is well done with the appropriate page numbers clearly marked next to the bird's name in both cases. The amount of information on each species is highly variable. The Bateleur Eagle, an obviously well studied species, occupies three whole pages, as does the Secretary Bird and many others, while some of the Petrels, for instance, are discussed in less than half a page.

The plates are the work of two artists, Peter Hayman (1-17) and Martin Woodcock (18-32). Unfortunately some of the plates are too crowded, because it was necessary to illustrate adults, subadults, and several immatures of certain species. Three of the four black and white plates, depicting birds of prey in flight, are so crowded as to be disturbing. Another criticism — birds are not numbered on the plates, but on a small scale counterpart of the plate found on the opposite page. This produces delays in identifying the birds, which even though this is a handbook and not a field guide, is a needless irritation. It is also a waste of space.

The last section of the book is a detailed, well arranged "Bibliography." It starts with general and regional references, which are followed by references for each family discussed in Volume I. Sources of sound recordings are also given. Finally there are three indices, for scientific names, English names and French names.

This is a commendable work — with reservations. The combination of large size and high price may deter otherwise interested ornithologists from acquiring this volume (and three more are to come!). It may be a sacrilege to suggest this, but a lighter weight, soft cover, more reasonably priced edition would greatly increase the usefulness of this important work.

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A Guide to Field Identification: Reptiles of North America.

By Hobart M. Smith and Edmund D. Brodie, Jr. 1982. Golden Press, New York (Western Publishing Company, Racine, Wisconsin) illus. 240 pp.

Over the past thirty years there has been an accelerating production of field guides to a multitude of groups of native animals and plants. Amphibians and reptiles are no exception. The Peterson series published by Houghton Mifflin Company, Boston, were the first modern guides with *A Field Guide to the Reptiles and Amphibians of Eastern and Central North America* by Roger Conant in 1958 (revised 1975), and *A Field Guide to Reptiles and Amphibians of Western North America*, by Robert Stebbins in 1966. These so well filled the need that they left little room for competition. Two attempted it by covering both groups for all of North America: *The New Field Book of Reptiles and Amphibians*, by Doris M. Cochran and Coleman J. Goin (1970, G.P. Putnam's Sons, N.Y.) and *The Audubon Society Field Guide to North American Reptiles and Amphibians*, by John L. Behler and F. Wayne King (1979, Alfred A. Knopf, N.Y.). In contrast to Isabel Hunt Conant's often hand-coloured, always carefully-posed, photographs and Stebbins' superb colour paintings and black-and-white drawings, these later books tried photographs of randomly-oriented animals sometimes in natural surroundings. The compression of both groups in a single volume made the accounts sparse and often unsatisfactory for identification.

Hobart Smith, a venerated herpetologist who had already authored 30 books and over 700 articles, accepted the challenge and, as an alternative to dividing the continent, has produced separate books for each class. The companion to the present volume, *Amphibians of North America*, was published in 1978 authored by Smith alone. In the *Reptiles of North America* Edmund D. Brodie, also a herpetologist of note, has joined him in coauthorship.

This book, as was its predecessor, is superbly organized and illustrated. Distribution maps, differentiating the range of each subspecies, are placed along the left hand side of the species descriptions. On the facing page each species, and occasionally distinctive subspecies as well, is illustrated in colour by David M. Dennis and Sy Barlowe (who did the illustrations for the amphibian volume). There are also diagrams of distinctive key patterns (usually scales, occasionally markings) that further differentiate grouped forms. All groupings are introduced by short sections containing general characters; comments on behaviour, habitat, and life history; and terse keys to the included forms. This layout has tremendous advantage and appeal as map, description, and picture of similar species are together in a single spread. It also has meant some drastic sacrifices. The maps are minute and their colour coding is given only once at the front of the book — a standard sequence of colours to correspond to numbered subspecies. In species with many subspecies, particularly ones with small ranges, a tiny map and faint colour often make an individual subspecies' range easy to overlook; in all cases they can only give a superficial impression of distribution. Space constraints also drastically limit the descriptions of species and subspecies but the adjacent map and illustration are partial compensation. Individual species comments on habitat and life history have been sacrificed to space conservation, but some of this information is in the group sections.

The general sections which precede (Introducing Reptiles, Snakebite, Reptile Names, How to use this Book, and Topography) and follow (Reptile–evolution; distribution; scales and scutes; skeleton; digestive, respiratory, circulatory, excretory and reproductive, and nervous and sensory systems; Reproduction, Dormancy, Enemies and Self Defense, Studying Reptiles, Keeping Live Reptiles, and Other Sources of Information) the species accounts are very succinct and informative. As would be expected of the progressive Hobart Smith, some departures from other standard works are inserted before their general acceptance has been adequately tested. *Elgaria* replaces *Gerrhonotus* for all but one of the Alligator Lizards. The term "brumation" replaces hibernation

to distinguish the dormancy of reptiles from the supposedly more complex physiological state in endotherms. Though proposed by W. Mayhew (1965, Biochemistry and Physiology 16:103-119) and supported by Whittlow (1973, pp. 201-258 *in* Evolution of thermoregulation III, Academic Press, New York) and Hutchinson (1979, pp. 207-228 *in* Turtles: perspectives and research, John Wiley and Sons, N.Y.) the new term's utility has been questioned (*see* Gregory, 1982, pp. 53-154 *in* Biology of the Reptilia, *Edited by* Carl Gans and F. Harvey Pough. Academic Press, New York). Common names, at least in Canadian species, follow the *Standard Common and Current Scientific Names for North American Amphibians and Reptiles* (Collins et al., 1978, Society for the study of Amphibians and Reptiles, Miscellaneous Publications, Herpetological Circular No. 7) in contrast to the earlier *Amphibians of North America* which coined novelities like "Peeper Treefrog", "Northern Chorus Frog", "Greater and Lesser Treefrog", and "Ensatina Salamander" in departure from the recommendations of the committee that Dr. Smith was a member of, perhaps because of a difference in the times of text preparation despite the coincident publication year.

This book, like its companion, is truly pocket sized and can be readily carried to the field. Together with its convenient layout this should maximize its actual field use and make it a valued supplement to the more detailed earlier guides. Although it facilitates the identification of reptiles in any portion of the continent, a Canadian may feel lost in attempting to pick out the 42 native forms from the 278 continental species presented; however, the convenient placing of the maps speeds elimination of southern species. This succinct, colourful and tightly-phrased, accurate guide is a worthwhile and modest investment for any herpetologist or naturalist.

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Mammals of the Northern Great Plains

By J. Knox Jones, Jr., David M. Armstrong, Robert S. Hoffmann, and Clyde Jones. 1983. University of Nebraska Press, Lincoln. xii + 379 pp. illus. U.S. $32.50.

This is a thoroughly researched, ably written account of the mammal fauna of the states of Nebraska, North and South Dakota. It has been put together by four veteran mammalogists. It incorporates much of the most recent information on the environment, vegetation, physiography, drainage patterns, soils, climate, mammalian communities, and zoogeography of the region, together with individual accounts of the 105 native and six introduced species found there. Several forms no longer likely to be encountered are included, notably the grizzly bear and caribou. Subspecies are discussed within the species accounts.

Individual accounts discuss the scientific and vernacular names for each species, their distribution, description, and their natural history. Photographs and range maps are included for virtually every species. While a glossary of most of the technical terms needed by mammalogists is appended to the text, some of those used in discussing vegetation and zoogeography might well have been included. Though these latter terms are generally familiar to specialists, the authors have also addressed their text to students and others interested in the subject. Many laymen will not have easy access to the specialized literature on these subjects to which the present authors refer.

Keys to the orders and families of mammals and a check list of the species covered are provided, together with a number of useful line drawings of skulls and dentition of many species. The bibliography appears to be full, with many monographs and articles representative of the most recent as well as the older literature. A brief addendum includes titles which appeared after this text first went to press.

The book is attractively printed and bound, and should enjoy long use as a desk reference for everyone interested in the mammals of the three states covered as well as adjacent states and provinces. It is strongly recommended as well to those concerned with wildlife management and conservation issues.

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Their Blood Runs Cold: Adventures with Reptiles and Amphibians

By Whit Gibbons. 1983. The University of Alabama Press, University. 164 pp. illus. Cloth U.S. $19.75; paper U.S. $9.95 plus $1 postage.

"... scientists still have a world of information to learn about herpetology. But what the average lay person knows about the subject is almost embarrassing for a country that espouses education and knowledge. We really need to try and do better."

On this pleading note (even more applicable to Canada than it is to the United States), Whit Gibbons concludes a lively text which ranges over a host of personal experiences. The vertebrates featured may be popularly termed "cold-blooded", but the writer brings anything but a chilling approach to his favorite ectotherms. Here he shares not only varied information on how reptiles and amphibians come to terms with their environment but also how herpetologists themselves come to terms with the sometimes enormous difficulties in their field research.

The book begins with a laudatory forward by Eugene Odum, and the mandatory author's acknowledgement of practical and moral aid ("to my wife Carol for constant support and a rather unusual tolerance"). An introduction discusses the U.S. Department of Energy's Savannah River Plant in South Carolina where much of Gibbon's work has been done and gives some preliminary insight into what the viewpoint of a herpetologist and ecologist encompasses.

The main body of the text is divided into 11 chapters: reptiles and amphibians, snakes, turtles, crocodilians, lizards, salamanders, frogs and toads, techniques in herpetology, more techniques, the future of reptiles and amphibians, and teaching the public. Each conveys some basics about the diversity and environmental relationships of a group, or (in the last especially) the public attitude to them. This is accomplished through well-chosen anecdotes which reveal as well the writer's enthusiasm, energy, and willingness to try new approaches. From his encounter with the medical world in the form of the fictiously named "Dr. Plunt", through close encounter with a Bushmaster, the catching of an alligator, the success of blowguns for stopping fast-moving lizards, a nightime competitive search for the elusive salamander *Phaeognathus*, to the excitement of a quest for the Bird-voiced Treefrog, each chapter begins like a safari tale but soon, almost imperceptively, heads to an outline of diversity, distribution, and ecology of a whole order. Most featured, however, are the animals whose study Gibbons' name is most closely associated in many minds, the turtles. They not only have their own chapter but also dominate those on techniques; the latter ranging from the use of inner tubes to Geiger counters. The concluding section is a reference primer in herpetology technical journals, state and regional guides for North America, textbooks, general works, and regional accounts listed by continent and country.

For those of us who have long admired Gibbons' professional papers it is a delight to find that his informal dimension is just as intense. An early comment on his own former ignorance and the change in personal attitude that occurred with increasing knowledge in herpetology; "I've watched the light come in ever so gradually" strikes far too passive a note. He hasn't just "watched"; he is a part of the expanding light which is diminishing our collective ignorance.

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BOTANY

The Rare Vascular Plants of Quebec

By A. Bouchard, D. Barabé, M. Dumais, and S. Hay. 1983. National Museum of Natural Sciences, Ottawa. Syllogeus 48. 75 pp. (English), 79 pp. (French). Free.

This is the seventh in the series of provincial rare plant reports published by the award-winning Rare and Endangered Plants Project of the National Museum of Canada. With each new volume we have come to expect increasingly more informative and authoritative studies. Because of this, and the vast area to be covered, this volume was eagerly anticipated by field botanists across eastern Canada. Sadly, it fails to match the achievements of recent previous volumes, let alone set new standards.

The problems begin in the Introduction. While it covers the basic areas of the previous Rare Plants Project volumes (*viz*, Methodology, Distribution of Rare Plants, etc.) it also suggests that the basic definition of rarity used in previous studies is too imprecise. After debating the merits of this and their "analytical approach", the authors end up differing, essentially, only by using "colonies" where others used "population". One wonders why they 'knock' the judgement of previous editor/authors when their own conclusions

are so similar. This discussion is followed by a fairly complete treatment of the distributional patterns of rare plants in Quebec. The Introduction concludes with an Acknowledgements section (that suggests, by omission, that a number of key specialists were not consulted in this study) and a discussion of rare plants protection in Quebec.

The main body of the text lists 408 rare vascular plants, each within a standard format that considers major synonymy, references, range (in Quebec and North America), published maps, habitat, and status (in Canadian provinces and U.S. states). Unfortunately, there are numerous errors in this section which detract from the study's credibility. References for one species are not cited for another just-as-appropriate species. Important literature for such genera as *Celtis, Pterospora* and *Chenopodium* (as well as for orchids and grasses) is missed altogether. Upon first reading I was able to identify over 60 omissions of pertinent literature citations and almost a dozen appropriate titles that were missed entirely! Hardly a confidence builder. It was as if each author took on one part of this report and prepared it in isolation from the others.

The nomenclature utilized is conservative - if not out-right dated. The use of *Habenaria* for *Platanthera* and *Thelypteris hexagonoptera* for *Phegopteris hexagonoptera* (to name but two of many examples) makes one wonder how thorough the literature review must have been.

From a review of sources identified in the Acknowledgements section and from gaps in the species accounts, what is perhaps the most significant failing of this study is apparent; many contemporary sources of important field data were ignored. The Ottawa Valley is considered an important center for rare Quebec plants, for example, yet very few of those actively botanizing the area over the last 10 years were contacted and important regional literature was ignored. I can only assume that this is the case for other regions as well.

A most perplexing omission is the absence of provincial range maps (in contradiction with all other Rare Plants Project literature since 1978). Since the distributional data were determined from a review of the major herbaria cited, why were these data not presented? As distributions are discussed in the text in usually less than 10 words, maps are vital. Another serious omission is the lack of a list of candidate species which were deleted from the final report. Such lists have been a part of Rare Plants Project reports since 1981. Does the absence of *Polygonella articulata* and *Silphium perfoliatum* (Quebec species described as Rare in Canada in previous Rare Plants Project reports but not mentioned in this one) mean that these species are no longer considered rare in Quebec? Or were they missed in this study? We have no way of knowing. Although an appendix listing species requiring further research before they can be considered is included, this does not alleviate the problem of 'missing' rare plants.

The results of this study are most disappointing because they only approximately replicate the standards of the *first* Rare Plants Project report that was produced six years previously. It is as if the authors were unaware of all the subsequent improvements and additions since that first effort in 1977.

Those interested in the rare flora of Canada will need to have this volume in their libraries if for no other reason than there is no other treatment of the rare Quebec flora. Unfortunately, they will also need a grain of salt when reading it.

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Intermountain Flora, Vascular Plants of the Intermountain West, U.S.A. Volume 4, subclass Asteridae (except Asteraceae)

By A. Cronquist, A. H. Holmgren, N. H. Holmgren, J. L. Reveal, and P. K. Holmgren. 1984. The New York Botanical Garden, Bronx, New York. 573 pp., illus. U.S. $75.

This is the third volume of the six proposed to be published for the Intermountain Flora. The first, Volume 1, which dealt with introductory materials, Pinaceae, Ferns and Fern Allies was published by Hafner Publishing Co. in 1972 and was reviewed in *The Canadian Field-Naturalist* 1973, 87: 329–330. The second, Volume 6, which dealt with the Monocotyledonae was published in 1977 by Columbia University Press and was reviewed in *The Canadian Field-Naturalist* 1978, 92: 312–313.

This volume comprises the Adoxaceae, Boraginaceae, Callitrichaceae, Dipsacaceae, Hippuridaceae, Hydrophyllaceae, Menyanthaceae, Pedaliaceae, Plantaginaceae, Polemoniaceae, Rubiaceae, Valerianaceae, Verbenaceae (by Cronquist), Lamiaceae, Cuscutaceae (by Cronquist and Reveal), Caprifoliaceae (by Cronquist and A. H. Holmgren), Solanaceae (by C. L. Hitchcock and Cronquist), Apocynaceae, Bignoniaceae, Buddlejaceae, Convolvulaceae, Gentianaceae, Lentibulariaceae, Oleaceae, Orobanchaceae,

Scropulariaceae (by N. H. Holmgren) Campanulaceae (by P. K. Holmgren) and Asclepiadaceae (by P. K. and N. H. Holmgren). Cronquist prepared the synoptical keys to the orders and families and descriptions of the orders and P. K. Holmgren acted as general editor.

The format follows that of Volumes 1 and 6, with keys, detailed descriptions, synonomy (with bibliographic references and type specimens), references, habitats, and distributions. As in the previous volumes, chromosome numbers are given, but there is no indication of whether these counts were made on specimens from the Intermountain Region.

A total of 42 nomenclatural transfers are made in the text. A list of these is provided on page 552.

Many of the drawings used in this volume are those of Jeanne R. Janish that were first published in *Vascular Plants of the Pacific Northwest*. New drawings for taxa not treated in that work have been done mainly by Janish, Bobbi Angell, and Robin Jess. A few have been drawn by Robin D. Brickman, Anneta Duveen, H.M. Fukuda, and William S. Moye. These fine line drawings will be most helpful in the identification of the various taxa.

Those interested in the flora of the Intermountain Region will be most pleased to see this latest volume of the series in print. It will be an invaluable reference tool. It is however now 12 years since volume 1 appeared. Hopefully, the remaining three volumes will appear more quickly because they are eagerly awaited.

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ENVIRONMENT

Marine and Coastal Systems of the Quoddy Region, New Brunswick

Edited by Thomas, M. L. H. 1983. Canadian Special Publication of Fisheries and Aquatic Sciences 64: Fisheries and Oceans Canada, Ottawa. x + 306 pp., illus. $17.95 in Canada; $21.55 elsewhere.

The Biological Station and the Huntsman Marine Laboratory at St. Andrews provide a centre for marine biological research and teaching in the Quoddy region of New Brunswick. The region encompasses Passamaquoddy Bay and the approaches to the Bay of Fundy north of Grand Manan Island. This publication is a synthesis of present knowledge on the structure and function of local marine systems. Designed as a reference for research scientists, students, and naturalists, it is strongly oriented towards teaching. Descriptions of specific systems are supplemented with detailed information on research techniques suitable for their study, and descriptions of the local sites most useful for their observation.

Preliminary chapters review the physical oceanography and meteorology of the region. These are followed by descriptions of intertidal and benthic biological systems, organized on the basis of substrate, and pelagic and terrestrial systems, organized primarily on the basis of major taxonomic divisions. Geological information is limited to that necessary for the classification of substrates. In the chapter on coarse sedimentary shores, Steele notes that the techniques and terminologies of geomorphologists have generally been adopted by biologists. Departures from standard methods have been introduced by biologists to provide a more useful structure for understanding the occurrence and behaviour of organisms on and within sediments.

The sections dealing with intertidal and benthic systems are the most successful in integrating all trophic levels with their environment. They provide descriptive, taxonomic analyses of communities. The relation of community structure to environmental gradients is discussed where appropriate. Quantitative descriptions of community structure are usually limited to estimates of biomass, cover or density. Classification by diversity indices and the use of multivariate techniques to demonstrate the affinity between stations, such as principal components analysis and cluster analysis, are lacking.

In the section on sublittoral sedimentary substrates, Wildish argues against the uncritical use of these parameters, on the basis that they frequently fail to clarify the physical and biological factors controlling community structure. Instead he employs the trophic ratio index. This classifies benthic sites on the basis of the relative numbers of deposit feeders and suspension feeders, which he relates primarily to the substrate stability of the site. This approach may be especially appropriate to the Quoddy region, where the large tidal range and variation in exposure of sites impose unusually strong physical influences on sublittoral communities.

The descriptions of some pelagic systems are disappointing. The chapter on fishes by Scott makes little

attempt to assess the structure of fish communities in the Quoddy region, or to relate them to other groups. The checklist and key to the fishes of the region are essentially available from his previous work (Leim, A. H., and W. B. Scott, 1966. Fishes of the Atlantic coast of Canada. Fisheries Research Board of Canada Bulletin 155). The section on phytoplankton reviews available studies on the seasonal changes in the flora and details a number of research techniques for taxonomy, biomass, and productivity, but offers little on production rates or processes controlling productivity in the region.

Zooplankton receive better treatment although the separation of microzooplankton and macrozooplankton is somewhat arbitrary. There is some justification since the majority of the larger species are not endemic to the region. These populations frequently originate outside the Bay of Fundy and occur sporadically in the Quoddy area. A number of the microzooplankton species have endemic subpopulations within Fundy. As a result their patterns of occurrence differ.

There is a good discussion of the oceanographic factors controlling the distribution of marine mammals and marine and coastal birds. The guides to sites for observing them are excellent. I question the inclusion of a guide to dissection of stranded cetaceans, but this is certainly a topic for which information is not easily accessible. The section on amphibians and reptiles is again primarily a guide to identification of the species found in the region, but does indicate the lack of information concerning ecological factors controlling their distributions and activity. In particular the use of nearshore habitats by these groups and the effects of brackish and salt water intrusions into their habitats are not well known.

This book provides a unique regional guide. The descriptions of many of the marine and coastal systems are comprehensive. The failure of some sections to explain more complex interrelationships of communities and to fully exploit quantitative techniques is disappointing, especially in a publication destined to be used as a text. In his introduction, the editor expresses the hope that this volume will serve as a stimulus to a better understanding of the Quoddy region. It should accomplish this.

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Geography of the Biosphere: An Introduction to the Nature, Distribution, and Evolution of the World's Life Zones

By Peter A. Furley and Walter W. Newey. 1983. Butterworths, London, England. xi + 413 pp., illus. U.S. $82.50.

The authors are Lecturers in Biogeography and Geography, respectively, with the University of Edinburgh. In the preface they state that their book is intended primarily for students of geography, especially undergraduates with little background in biology or other sciences. Therefore, they have written a book that undertakes to provide students having little knowledge of biology with the background necessary to understand a very complex subject. The result is an introductory text that treats virtually every aspect of basic biology, ecology, evolution, and distribution relating to the broad subject of biogeography. The authors' approach to the subject is traditional, with emphasis on the major biomes and on the edaphic and climatic factors that help to determine their distribution and composition. Overall, I think the authors have succeeded well. This is not an encyclopedic reference that professionals and advanced students will want to refer to in conducting their own reserach, but as an introduction to the field of biogeography it is quite good, if somewhat superficial.

The book is divided into six parts. In the introduction the authors explain their emphasis on an ecosystems approach. As geographers they are interested in large scale patterns and their causes. Thus, much of the book is devoted to the global-scale ecosystems or biomes, their distribution and constituent plant and animal communities, and the climatic and edaphic factors that determine the limits of the biomes.

The second part deals with the nature of energy and the circulation of matter. Global patterns of solar radiation, photosynthesis, and primary production are described, and the flow of energy through food webs is examined. Then biogeochemical cycles are briefly examined.

Part 3 is a survey of the component systems of ecosystems. The first component system covered is soil, followed by plants, and then animals. The chapter on soils is almost one and one-half times as long as either of the other two, and treats soil chemistry, structure, analysis, formation, classification, and distribution, indicating the importance that the authors place on soils. In the chapters on plants and animals basic biology, classification, and ecology are discussed, with emphasis on environmental relationships.

Part 4 deals with the evolution of these three systems, and begins with a very rapid discussion of evolu-

tionary theory. The origin of the terrestrial biota and the influence of plate tectonics as historical determinants of community composition and distribution also are briefly discussed. I found the discussion of soil evolution the most interesting, perhaps because it is a topic not covered in such detail in most ecology texts.

Part 5 comprises the heart of the book. This is the discussion of the major biomes and their distribution. These are treated from the poles to the equator, from tundra to temperate to tropical terrestrial biomes, to marine and freshwater ecosystems. Each biome is analyzed in terms of its plant and animal components and the predominant soil types. The influence of man's activities are discussed where appropriate, especially under the tundra and tropical biomes.

The last part is a short discussion of automated mapping and remote sensing as tools available to the modern geographer. These sections were contributed by R. P. Kirby and J. McG. Hotson, also of the University of Edinburgh.

The text is well illustrated throughout with numerous good line drawings. In addition, there is an abundance of informative tables that contribute to the discussion in the text.

I enjoyed this book; however, because it attempts to provide so much information in such little space, it obviously is deficient in detail in many places. I doubt that anyone could study the section on evolution and come away with a clear understanding of the subject, for instance. I think the authors have done well, but the book is far too expensive to be used as a required text, and it is not detailed enough to serve as a reference for a professional researcher. In light of the job the authors have done, this is unfortunate.

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Once A River — Bird Life and Habitat Changes on the Middle Gila.

By Amadeo M. Rea. 1983. University of Arizona Press, Tuscon. 285 pp. U.S. $24.50.

Conservationists throughout North America should be alarmed by the habitat destruction that has been wrought by the white man since his arrival. Grasslands and forests alike have been replaced by monoculture crops or by asphalt and concrete, lakes and marshes have been drained, and the list goes on. One of the worst ecological atrocities yet reported involves the Middle Gila River, which runs through the Gila Indian Reservation in southern Arizona. Amadeo Rea not only tells us how this river has been totally depleted, and the land left without its life source, but offers a fascinating mixture of history, ethnography, archaeology, ecology, and ornithology. Although an obvious labour of love, the facts are presented unemotionally, leaving the reader to form his or her own conclusions.

Rea begins with the history of the Pima Indians in this delicately balanced, arid region, so susceptible to human-induced influences, and then tells of the arrival of white men. When the Jesuit missionary Eusebio Kino visited the Gila River in 1697, he described its "very large cottonwood groves" and said that "its inhabitants . . . fish all the year, sustaining themselves with the abundant fish and with their maize, beans, and calabashes." Ironically the cattle introduced by Kino into the southwest indirectly and gradually initiated the destruction of the Gila river-edge and adjacent grassland habitat. When 60 000 Anglo travellers passed through the Indian villages during the gold rush in 1849, the Gila was still 100 yards wide and flowed at six miles per hour. Subsequently, the area suffered from "cutting, chopping, damming, gouging, bulldozing, levelling, pumping, ripping, poisoning and grazing . . . all in the name of Progress."

The 150 000-acre Gila Reservation, which reaches to the southern suburbs of Phoenix, has been dammed and grazed and gullied to death. The groundwater table, once near the surface, is now 100 feet beneath. In places the only grasses of importance are imported Mediterranean weeds. Farming is largely by white farmers from off the reservation. No natural vegetation of any kind persists on some of these large leased farms, which raise monocultural crops, principally cotton. Fossil groundwater is pumped from wells hundreds of feet deep into concrete-lined ditches. Incredibly, trees have been bulldozed as a "flood control measure." These destructive habitat changes are carefully documented by Rea.

By the time the first resident ornithologists, George F. Breninger in 1901 and M. French Gilman from 1907 to 1915, appeared on the reservation, there was already a greatly reduced surface flow of water and lowering of groundwater levels. The Breninger and Gilman records have allowed Rea to describe the drastic changes in bird distribution that have occurred in the last 70 years, and to list the bird species that remain in each of 11 habitat types.

Rea then proceeds to the species accounts, which form over half the book. He shows old-fashioned rigour in listing species as hypothetical unless there is

an extant specimen or photograph for the immediate area. The Whistling Swan, for example, is listed as hypothetical because Gilman's 1910 specimen no longer can be located.

Under the "Archaeological" heading, Rea lists about 30 species of birds for which osteological remains have been excavated, from sites dating back to 300 B.C. Under "Ethnographic" Rea makes an extremely valuable contribution. He interviewed knowledgeable native informants, and unlike so many lexicographers and compilers of native language dictionaries, he knew the questions to ask. A surprising number of Pima Indian names for birds are onomatopoetic. Rea also provides pertinent local Indian legends, details of how Red-tailed Hawks and Golden Eagles were kept in cages in Indian villages, and how Lark Buntings and White-crowned Sparrows were once important winter food items. He quotes Pima songs about the American Kestrel and sandpipers. The Northern Harrier is considered a harbinger of winter. If an Indian child is slow to learn to talk, he is fed mockingbird meat.

Historic and Modern sightings are then reported for each species, noting that 29 species have been extirpated from the Gila River reservation, and another 17 have decreased drastically in numbers.

Finally, Rea disagrees with many taxonomic decisions of the American Ornithologists' Union Committee, and spends much time explaining, largely on the basis of osteology, his opinion as to the relationship and proper classification of a number of bird species.

All in all, this unique and beautifully illustrated book contains lessons of value to all of us, no matter where we live. The Canadian prairies can be almost as dry as southern Arizona, most government pastures are being converted to exotic grasses, and in 1984 we may have insufficient water for the irrigated lands in southern Alberta. If we can only learn from Rea, we need, I hope, never point to the Oldman valley, and say this was "once a river."

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MISCELLANEOUS

Looking Far North: The Harriman Expedition to Alaska, 1899

By William H. Goetzmann and Kay Sloan. 1982. Princeton University Press, Princeton. xxv + 244 pp., illus. U.S. $8.95.

Edward Henry Harriman (1848–1909) is probably best remembered today as an aggressive pioneering railroad entrepreneur and as a figure in the landmark Northern Securities case of 1902, which opened President Theodore Roosevelt's campaign against certain large American trusts of that era. Less well known is the Harriman Alaska Expedition of 1899, which was another of the magnate's brain children and which made some useful contributions to scientific knowledge.

The senior author of this account is a well known historian at the University of Texas, with a number of highly acclaimed studies of the American West to his credit. His co-author is a departmental colleague. What they have assembled here is in the main history, rather than history of science; the book is perhaps best summed up by *Publishers Weekly* as "an absorbing travel story." Yet it also offers some useful insights into this summer voyage to Alaska which is described by the authors as "perhaps the last grand expedition of the nineteenth century."

Harriman walked into the office of Dr. C. Hart Merriam, then Chief of the U.S. Biological Survey in Washington, one day in March, 1899, and made inquiries about how he might go about organizing a scientific expedition to Alaska. Such ventures were not inexpensive, even by the standards of that day. Merriam, who knew a great deal about organizing scientific trips but little of railroad management and nothing of Harriman, assumed that his caller, who proposed to underwrite the services of a ship and ships' crew, together with several dozen scientists and savants, was out of touch with reality. He went around to Harriman's Washington offices to inquire as to whether Harriman was known there and whether he had any money. He was flabbergasted to discover that Harriman possessed millions.

Merriam was then persuaded to organize the scientific side of the expedition, calling upon some of the leading naturalists and other scientists of the day. John Burroughs and John Muir were probably the best known of the assembled party to the general public. Others included the paleontologist W. H. Dall, the zoologist D. G. Elliot, B. E. Fernow, the first professional forester in the U.S., the geographer Henry Gannett, the geologist G. K. Gilbert, George B. Grinnell, ornithologist, anthropologist, and publisher, and Robert Ridgway, the ornithologist. The entire party of 126 persons, including the Harriman family and servants, several artists and taxidermists, two doctors, a nurse, two photographers and a chaplain, set sail from Seattle in the rented vessel *George*

W. Elder on May 30, 1899 and returned exactly two months later. Harriman was a generous patron, and the ship came back loaded to the gunwales with souvenirs of the trip, including one full-length totem pole.

Goetzmann and Sloan get to the essence of the Expedition's scientific accomplishments in their final chapter, where they emphasize that "all of the scientists involved recognized that the expedition was a reconnaissance rather than a comprehensive or definitive survey of the region." One exception was Gilbert's study, *Glaciers and Glaciation*, later published as one of the thirteen published *Harriman Alaska Expedition* reports edited by Merriam between 1901 and 1914. Gilbert was "able to analyze the behavior . . . of glaciers as no one had done before him."

Merriam's own projected volumes on the mammals collected on the expedition were never completed, because of the pressure of other commitments on that overworked official. Yet the Harrimans did not forget his services. E. H. Harriman died in 1909, but his widow Mary was persuaded to grant Merriam an annual subvention of $12 000 in salary and research expenses in 1910. This made it possible for Merriam to continue his multifaceted research efforts on an independent basis for nearly thirty years.

The authors also make clear the superb accomplishment of the photographer Edward S. Curtis in capturing the essence of the Alaskan landscape.

While their bibliography appears to be extensive, it might have been helpful to provide complete bibliographical data for the published *Harriman Alaska Expedition* reports for the benefit of interested readers.

The authors had to work around certain obvious gaps in the literature in the course of their research. E. H. Harriman's papers, for example, were destroyed by fire in 1913. They have, however, located a good deal of other material, from which they have effectively synthesized a well told tale.

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NEW TITLES

Zoology

***The amphibians of British Columbia.** 1984. By David M. Green and R. Wayne Campbell. Handbook 45. British Columbia Provincial Museum, Victoria. viii + 100 pp., illus. $3.

A beast the color of winter: the mountain goat observed. 1983. By Douglas H. Chadwick. Sierra, San Francisco. viii + 208 pp., illus. U.S.$15.95.

The behavior and ecology of the African buffalo. 1983. By Mark J. Mloszewski. Cambridge University Press, New York. 245 pp. U.S.$37.50.

Bird migration. 1983. By Chris Mead. Facts on File, New York. 224 pp., illus. U.S.$19.95.

Birds of the world: a survey of the twenty-seven orders and one hundred and fifty-five families. 1983. By Oliver L. Austin, Jr. Golden Press, New York. 317 pp., illus. U.S.$24.95.

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ISSN 0008-3350

The CANADIAN FIELD-NATURALIST

Published by THE OTTAWA FIELD-NATURALISTS' CLUB, Ottawa, Canada

Volume 99, Number 2

April-June 1985

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Cover: Painted Lady butterfly, *Vanessa cardui*, Waterton National Park, courtesy of A. N. Wiseley (photographer). See article by M. T. Myres, pp. 147–155.

The Canadian Field-Naturalist

Volume 99, Number 2 April-June 1985

Initial Response of Moose, *Alces alces*, to a Wildfire in Interior Alaska

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Gasaway, William C., and Stephen D. DuBois. 1985. Initial response of Moose, *Alces alces*, to a wildfire in interior Alaska. Canadian Field-Naturalist 99(2): 135–140.

The initial response of seven radio-collared Moose (*Alces alces*) to wildfire was investigated to determine if Moose were displaced from the burned portion of their home ranges. Home ranges of these Moose overlapped a 500-km² fire that burned from 3 May-20 June 1980 in interior Alaska. By comparing relocations and home ranges of animals from May-August of the two years preceding the fire to data in the year of the fire, we concluded radio-collared Moose were not displaced. Moose selected primarily unburned sites within the perimeter of the fire.

Key Words: Moose, *Alces alces*, wildfire, Alaska

The immediate effect of wildfire on wildlife is often perceived as animals fleeing from flames. Although some examples support this concept (Komarek 1969), little is known about the response of Moose to wildfire (Kelleyhouse 1979). Hakala et al. (1971) observed no Moose fleeing from approaching flames of a 348-km² fire on the Kenai National Moose Range, Alaska. Komarek (1969) indicated that large mammals usually escaped without panic along the sides and flanks upon determining the fire's direction. Conversely, Udvardy (1969, cited in Bendell 1974) reported a chaotic incident of Moose and other animals escaping wildfire by swimming across large rivers. In Manitoba, a large, fast-moving fire (809-km² in 8 hours) killed and scorched some Moose and other wildlife unable to escape (V. Crichton, personal communication).

Our objective was to determine if radio-collared Moose were displaced from the burned portion of their traditional home ranges during and/or shortly after a large wildfire in interior Alaska. This information will help Moose managers predict effects of wildfire on Moose, on postfire Moose population density, and on potential population growth. If most Moose are displaced from their home ranges either permanently or for many years, Moose population regrowth would be slow or highly dependent upon immigration. Where Moose density is low adjacent to the burn, immigration may not significantly contribute to population growth. Conversely, if Moose that traditionally used the burned area remained in their established ranges, then they could contribute substantially to population growth in the burn, and there would be less need for concern by wildlife managers, fire suppression personnel, and the general public about the welfare of Moose during and after wildfires.

Study Area

The interior Alaska study area, located on the Tanana Flats lowlands (Figure 1), supports a mosaic of

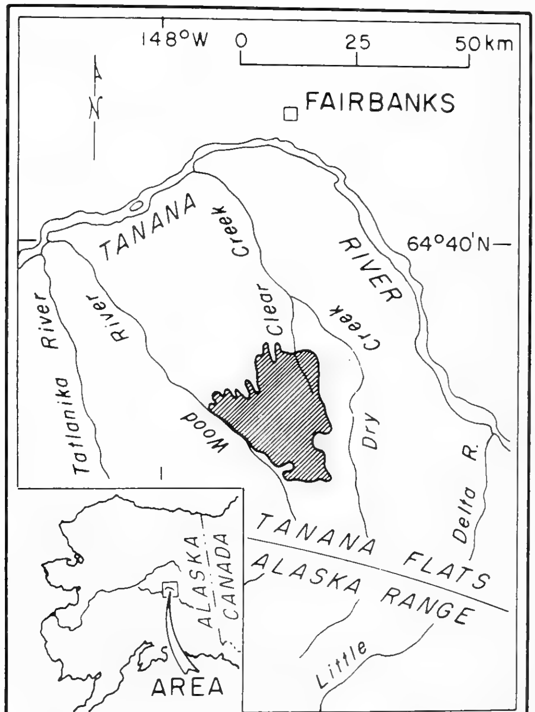

FIGURE 1. Location of the 500-km² wildfire (shaded area) that burned on the Tanana Flats, Alaska from 3 May-20 June 1980.

habitat types including herbaceous bogs, shrub-dominated seres following numerous wildfires, deciduous forest, and Black Spruce (*Picea mariana*) and White Spruce (*P. glauca*) forests (LeResche et al. 1974).

A 500-km^2 wildfire burned on the Tanana Flats from 3 May-20 June 1980. The fire burned an area of predominantly mature Black Spruce and Aspen (*Populus tremuloides*) forest, which supported a Moose density of approximately 0.1 moose/km^2.

In that portion of the burn traditionally used by radio-collared Moose, about 75% of the area was moderately to severely burned, about 10% lightly burned, and about 15% unburned. Basal sprouting of willows (*Salix* spp.) occurred during summer 1980. An average of 58% (SE 8, *N* 7, range 20-76) of the 1980 home ranges occupied from 29 April-August were inside the fire perimeter.

Methods

We tested the following hypotheses: (H_o) wildfire does not displace Moose from burned portions of home ranges, (H_a) wildfire displaces Moose from burned portions of their traditional home ranges. A wildfire in May and June 1980 burned portions of home ranges of five radio-collared cow Moose and two radio-collared bulls. To determine if the fire displaced Moose, locations and home ranges of radio-collared Moose during 29 April-August 1980 were compared to similar data from the same Moose during 29 April-August of 1978 and 1979. The 1978 and 1979 Moose movements identify traditional home ranges and serve as controls for detecting effects of wildfire on home ranges. The number of relocations from 29 April-August for individual Moose ranged from 8-11 in 1978, 4-7 in 1979, and 4-6 in 1980 prior to and during the fire and 2-5 after the fire. Only four of the seven Moose were radio-collared in 1978. Home ranges were drawn using the minimum home range method (Mohr 1947). Subjective visual comparisons between the 1978-79 and 1980 home ranges of each Moose helped to determine if displacement occurred. We realize the limitations of home range polygons drawn from a small sample of locations.

In testing the hypotheses, H_o will be rejected if: (1) a X^2 test shows significantly fewer ($P < 0.05$) relocations of Moose are found in the burn perimeter during 1980 than are expected, based on 1978 and 1979 relocations, and (2) a significantly ($P < 0.05$) greater percentage of 1980 home range polygon area is outside the burn perimeter when compared to percentages for 1978 and 1979; the test is Wilcoxon's signed ranks procedure (Hollander and Wolfe 1973). If we fail to reject H_o, we will inspect the data to determine if we want to make a heuristic argument for acceptance of H_o. If we reject H_o, inspection of data will be used to heuristically argue to accept H_a.

In 1980, Moose were recorded as being inside or outside the fire perimeter. If inside, the site selected by the Moose was recorded as burned or unburned. All relocations were made from fixed-wing aircraft and plotted on 1:63 360 maps.

To determine the percentage of radio-locations from 1978 and 1979 that were in the 1980 burn, each location was compared to a map showing the chronological advance of the fire perimeter. The Moose was determined to be in the area burned during 1978 or 1979 if the location was within the burn perimeter for that day in 1980. Therefore, when the burned area was small, a 1979 point could have been recorded out of the burn, yet later when the burned area had enlarged the same location could have been in the burn. The advance of the fire was monitored by the Bureau of Land Management and the Alaska Department of Natural Resources, Division of Forestry during fire suppression activities. Chronological advance of the fire's perimeter was drawn on 1:63 360 maps. The intensity of the burn, based on criteria of Viereck and Schandelmeier (1980), was assessed during aerial and ground level surveys.

Results

We accepted H_o because we did not statistically reject H_o and inspection of data provided no evidence that fire displaced Moose from the general area used 1-2 years prior to the fire. The number of relocation points inside the fire perimeter in 1980 did not decline ($P > 0.05$) compared with 1978 and 1979 (Table 1). The mean percentage of May-August home range area outside the burn perimeter was not greater in 1980 (42%, SE 7.7, *N* 7) than in 1978 and 1979 (57%, SE 8.6, *N* 11). In addition, May-August home ranges in 1980 overlapped 1978 and 1979 ranges by an aver-

TABLE 1. Percentage of relocations for seven radio-collared moose within an area burned by wildfire on the Tanana Flats, Alaska.

	1978-79 (pre-burn)		1980		
Month	*N*	%	*N*	%	Status of fire
May	37	11	11	9	Burning
June	17	12	20	50	Burning
July	6	17	8	75	Postburn
August	8	63	9	78	Postburn
Total or mean of means	68	26	48	53	

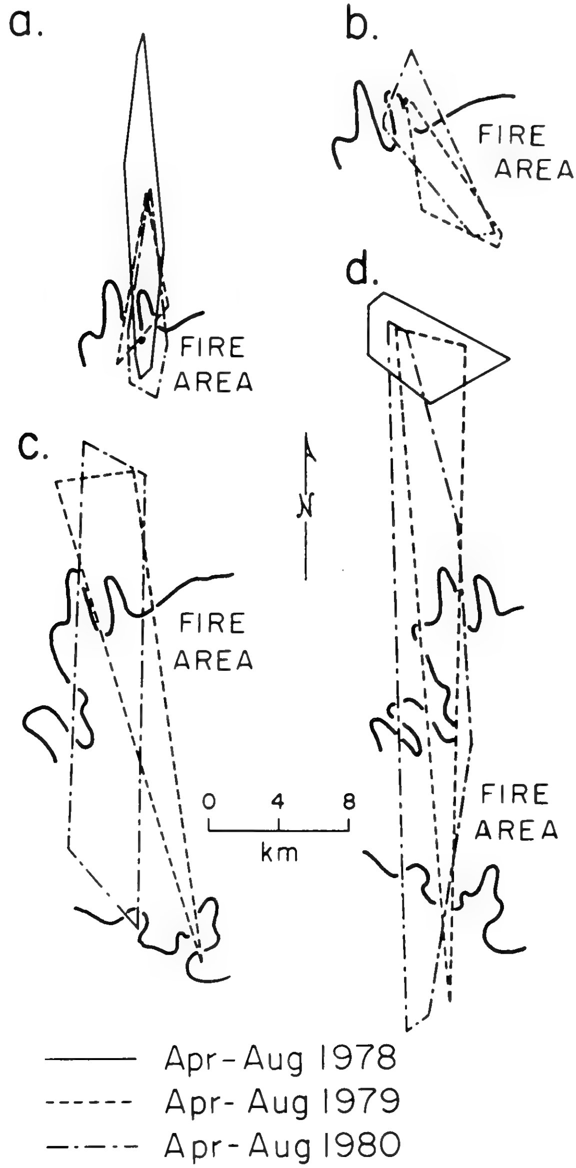

FIGURE 2. Home ranges of four radio-collared Moose for 29 April-August 1978, 1979, and 1980 in relation to a wildfire that burned from 3 May-20 June 1980 on the Tanana Flats, Alaska.

age of 46% (SE 7, *N* 11). Visual inspection of these prefire and 1980 May-August home ranges shows nonoverlapping portions of ranges were spatially close and the long axes were generally parallel (Figures 2, 3). These data indicate the fire had little effect on the shape and location of home ranges.

Moose showed no reluctance to use that portion of their range within the fire perimeter while the fire was burning and producing dense smoke (Figure 4). Fifty percent of all June 1980 relocation points were inside the fire perimeter (Table 1) and, on two occasions, Moose were seen standing within 2 and 15 m of small

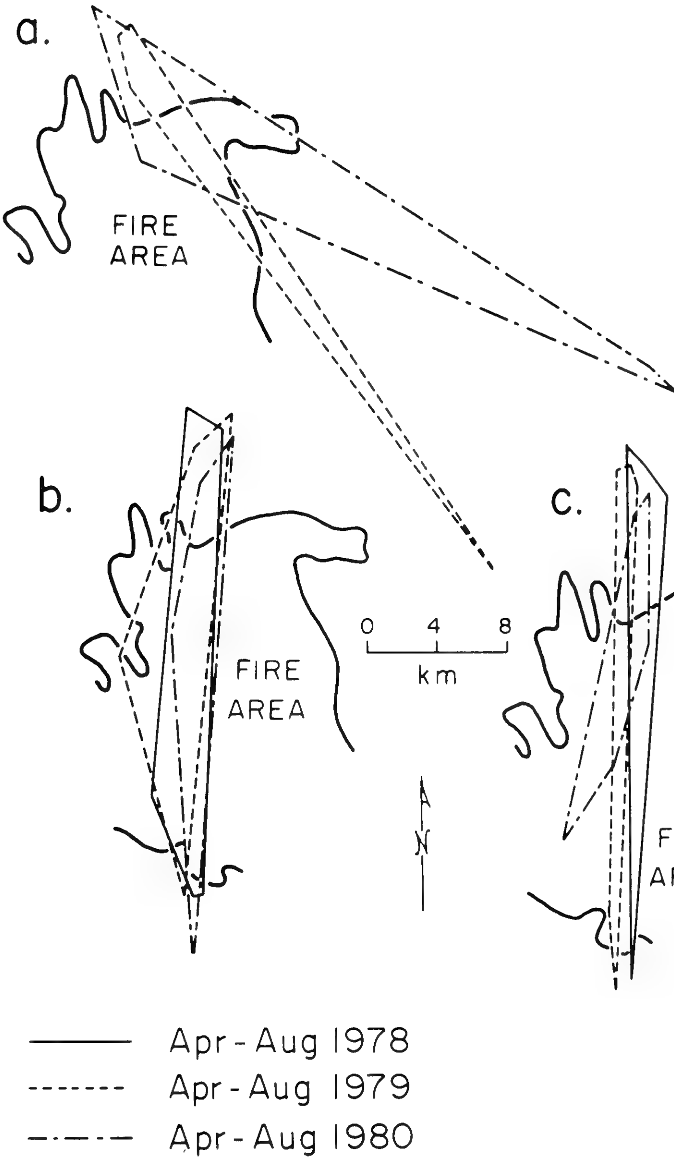

FIGURE 3. Home ranges of three radio-collared Moose for 29 April-August 1978, 1979, and 1980 in relation to a wildfire that burned from 3 May-20 June 1980 on the Tanana Flats, Alaska.

flames. These two Moose appeared unconcerned about the flames.

When Moose were within the perimeter of the burn, they showed strong selection for unburned vegetation (X^2, $P < 0.01$). Although only approximately 15% of the vegetation remained unburned, radio-collared Moose were located in unburned sites 67% ($N = 30$) of the time.

Discussion

Moose were not displaced from their traditional May-August home ranges when a portion of their range was altered by fire. Unburned vegetation apparently met their immediate food and cover requirements and may have been the main factor initially enabling them to remain within their ranges. Unburned vegetation outside the fire perimeter and as

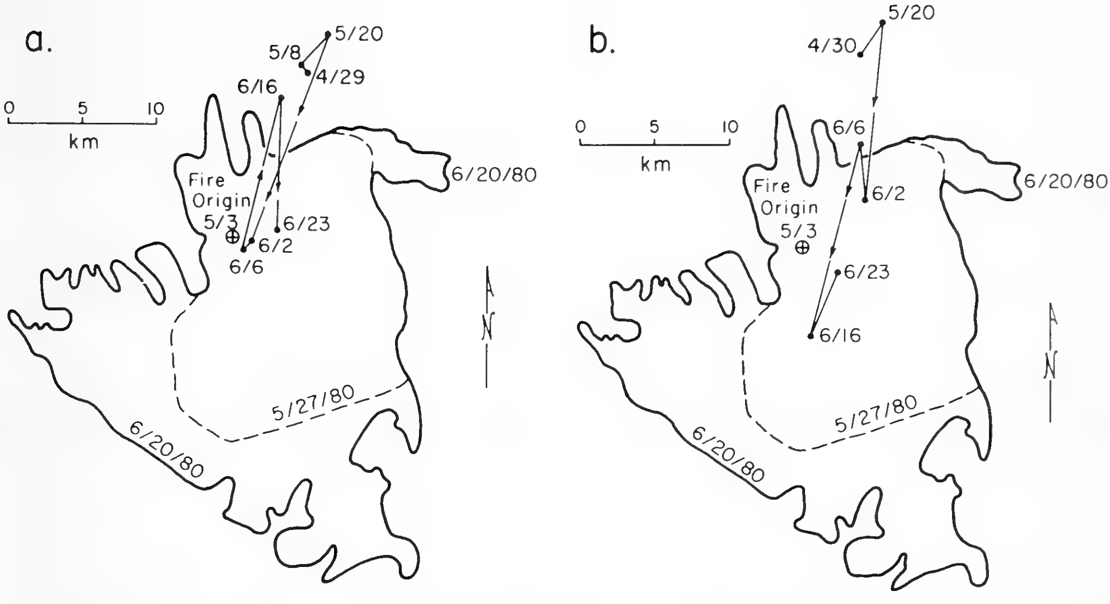

FIGURE 4. Movements of two radio-collared Moose from 29 April-23 June 1980 in relation to a wildfire that burned from 3 May-20 June 1980 on the Tanana Flats, Alaska. Intermediate (dashed line) and final fire perimeter (solid line) are shown.

"islands" inside the fire perimeter was used (Figure 4). Additionally, Moose had resprouting browse available in the burned area during summer 1980; therefore, their food base quickly increased.

Data in Table 1 appear to indicate that Moose were attracted to the burn area during June and July 1980, but we hesitate to draw this conclusion. Movements of each Moose viewed independently showed no clear shift of home range into the burn during 1980 as compared with other years.

Large wildfires in interior Alaska commonly burn mature or climax forests, which generally have low Moose densities (0.1-0.2 Moose/km^2; Gasaway and DuBois, unpublished data); therefore, few Moose will be associated directly with wildfires. Moose that are in contact with wildfires similar to the one we observed may not be adversely affected and probably will remain in their home range. In contrast, extremely hot, large, and fast-moving wildfires that leave few unburned inclusions may occasionally kill or temporarily force Moose to abandon their home ranges. These factors should be considered when planning prescribed burns or managing wildfire to benefit low density moose populations. When moose density is high adjacent to burns, type of burn is of lesser long-term importance because of the potentially high rates of immigration, as observed in Minnesota (Peek 1974). Additionally, burning in spring or early summer allows some forage regrowth in the same year, thus providing a widespread food source. Burning in late summer or fall in northern latitudes will delay vegetative regrowth until the following spring, which could be a factor in forcing Moose to abandon portions of their home range.

The consequences of home range abandonment and the resultant slowed population growth are significant to people dependent on Moose for food and recreation in interior Alaska and northern Canada. Moose density is currently low over much of the area, and this can have a bearing on the long-term response of Moose to burned areas. When Moose density is low and well below carrying capacity, there is neither a reservoir of Moose nor the competitive incentive for Moose to immigrate into burns. Therefore, growth of low density Moose populations may be primarily dependent on production by Moose that traditionally occupied the area (Gasaway et al. 1980). Under favorable conditions, Moose populations can double in 3-4 years (finite rate of growth = 1.2-1.25) (Gasaway et al. 1983; Keith 1983), hence the starting Moose density is an important determinant of future Moose densities and availability of Moose for use by humans.

Acknowledgments

We thank Diane Preston for assistance with data collection, Dan Reed for statistical advice, and Joann

Barnett, James Peek, and Wayne Regelin for reviewing a previous draft. This work was funded by Federal Aid in Wildlife Restoration Project W-21-2.

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Received 24 January 1983
Accepted 27 November 1984

More New and Interesting Grass Records from Southern Ontario

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Webber, J. M., D. McLeod, and R. S. W. Robbette. 1985. More new and interesting grass records from southern Ontario. Canadian Field-Naturalist 99(2): 141–146.

Specimen citations and comments on nomenclature, taxonomy, distribution and ecology of certain grasses which represent additions to the flora of Ontario, Canada, or significant range extensions in southern Ontario are presented. One grass is an overlooked, native species which is rare in Ontario and the others are North American or European introductions. The seven taxa are X *Agrohordeum macounii, Anthoxanthum odoratum, Bromus squarrosus, Distichlis stricta* var. *dentata, Elymus elongatus* subsp. *ponticus, Poa sylvestris,* and *Stipa comata.*

Key Words: grasses, Ontario, distribution, introduced plants, rare plants.

The recent monograph *Grasses of Ontario* has facilitated determination of the status of grass records in this province, even though the distribution maps have been little changed since 1971 (Dore and McNeill 1980). Recent interest in the overlooked flora of the Carolinian Zone (Soper 1962) and the introduced flora of disturbed habitats resulted in 11 additions to the grass flora of Ontario (Catling et al. 1977). As a result of botanical investigation in similar, overlooked habitats, we report the following five taxa as new to Ontario: *Bromus squarrosus, Distichlis stricta* var. *dentata, Elymus elongatus* subsp. *ponticus, Poa sylvestris* and *Stipa comata.* Two of these, *Elymus elongatus* subsp. *ponticus* and *Poa sylvestris*, are new to Canada. Of the five taxa new to Ontario, only *Poa sylvestris* is a native species and it is restricted to the Carolinian Zone; two, *Bromus squarrosus* and *Elymus elongatus* subsp. *ponticus,* are European introductions; and the remaining two, *Distichlis stricta* var. *dentata* and *Stipa comata,* are western North American species found in Ontario at sites where introduction seems likely. Two additional grasses, the intergeneric hybrid X *Agrohordeum macounii* and the European *Anthoxanthum odoratum,* are discussed as recent records new to southern Ontario.

These seven grass taxa are listed alphabetically below. Specimen citations are followed by comments on nomenclature and taxonomy necessary for identification. The known distribution and ecology of these grasses in Ontario are briefly discussed.

X *Agrohordeum macounii* (Vasey) LePage (= *Elymus macounii* Vasey) *Peel County:* City of Mississauga, southwest corner of Dixie Rd. and the QEW, inside traffic circle, *J. M. Webber 3114,* 22 August 1980 (CAN, DAO, TRTE); Albion Tp., about 2 km northeast of Palgrave, railway embankment just east of Gibson Lake, *J. M. Webber* (and J. M. Kaiser) *3931,* 2 August 1981 (TRTE).

X *Agrohordeum macounii* (Macoun Wild-rye) is an intergeneric hybrid between *Agropyron trachycaulum* (Wheat Grass) and *Hordeum jubatum* (Foxtail Barley) (Boyle and Holmgren 1955; Gross 1960). Formerly called *Elymus macounii,* X *Agrohordeum* differs from *Elymus* in having 2–3 spikelets at each joint in the rachis, rather than the usual 2 of *Elymus.* Because X *Agrohordeum* is sterile, it is easily distinguished from *Elymus* after careful examination.

Dore and McNeill (1980) report three stations of this grass in Ontario: Thunder Bay, Longlac (Thunder Bay District) and Kapuskasing. As these localities are all in northern Ontario, the two records from the southern and northern parts of Peel County represent significant range extensions. Dore and McNeill (1980) postulate that this intergeneric hybrid results from F^1 seed formed in the prairie provinces, where both parents are common and hybridization occurs frequently. They suggest that two of the northern Ontario collections from railway embankments resulted from seed transported from the west, but that one might be the result of local hybridization. The former explanation seems plausible for the Albion Township (Peel County) record, which occurred on an embankment of the C.P.R. The Mississauga (Peel County) record, however, occurred in a depression in a grassy traffic circle. At both sites one parent species, *Hordeum jubatum,* was present, but there were no specimens of *Agropyron trachycaulum,* a rare grass in Peel County (Webber 1984). Single clumps occurred at both Peel County localities. No trace of these was found in subsequent years, although only a portion of each clump was collected.

Anthoxanthum odoratum **L.** *Middlesex County:* London, Reservoir Park, edge of lawn next to woods, *D. McLeod,* 25 May 1980 (UWO, personal herbarium DM). *Peel County:* Caledon Tp., cemetery about 2 km north of Cheltenham, *J. M. Webber* (and J. M. Kaiser) *4219,* 30 May 1982 (CAN, DAO, TRTE). *Simcoe County:* Orillia Tp.: Lot 18, Concession XIII, west bank of Severn River, 3 miles northwest of Severn Bridge, *R. S. W. Bobbette 3819,* 11 August 1973 (personal herbarium AAR); Lot 16, Concession XIII, 2¼ miles west of Severn Bridge, *A. A. Reznicek 3924,* 11 May 1973 (personal herbarium AAR); Orillia, north end of Couchiching Park, *R. S. W. Bobbette 4699,* 14 June 1976 (personal herbarium AAR); Oro Tp., Lot 18, Concession IV, 6½ miles northeast of Barrie, *A. A. Reznicek* (and S. A. White) *4904,* 15 July 1977 (personal herbarium AAR). *Welland County:* base of Point Abino, *P. M. Catling and A. A. Reznicek,* 11–15 June 1981 (DAO, MICH).

Anthoxanthum odoratum (Sweet Vernal Grass) is a distinctive, introduced species which is readily identified by keys in Dore and McNeill (1980). They believe that it arose from meadow and lawn seed mixtures imported from Europe. *Anthoxanthum odoratum* is a common weed in the Maritime Provinces and adjacent northeastern United States, as well as coastal British Columbia. According to Dore and McNeill (1980), all southern Ontario records are more than 50 years old. Plants on which these records were based may have persisted for a short time before succumbing to summer drought. The recent collections cited above indicate that this species may be more common than once believed. There are other recent records from Parry Sound and Muskoka.

It is interesting that the only Peel record (Webber 1984) occurred on the Niagara Escarpment. This area has highest annual rainfall in the County (86 cm) and this may reduce the severity of summer drought. Here *Anthoxanthum odoratum* was found in an old, untended cemetery. Had the lawn been mowed, it would certainly have been overlooked.

Bromus squarrosus **L.** *Kent County:* Erieau Beach, *J. Laudenbach* (and C. Campbell) *130,* 22 June 1975 (TRTE); Harwich Tp., west of highway junction at Ridley, about 5 km west of Morpeth, *J. M. Webber 4373,* 18 June 1982 (CAN); Erieau, dry, open waste places near Lake Erie, *M. J. Oldham 3853,* 24 June 1983 (TRTE).

This Brome Grass, which resembles *Bromus japonicus* (Japanese Brome), is readily identified in Voss (1972). The lemmas of our specimens of *B. squarrosus* are 2.5–3.2 mm wide, whereas those of *B. japonicus* are less than 2.2 mm. In addition, the awns of *B. squarrosus* are spread at right angles to the spikelet, whereas in *B. japonicus* they are not so widely spreading. If our specimens were identified by means of keys in Dore and McNeill (1980), they would incorrectly run to *B. japonicus.*

Bromus squarrosus was first collected in Michigan in 1932 (Voss 1972). Since then it has been reported as spreading along railroad tracks (Voss 1972) and is now scattered throughout Michigan. Although one of us (JMW) has collected plants in Kent County infrequently, she has found it twice in the vicinity of Rondeau Provincial Park. It was sparse on a sandy beach at Erieau in 1975; however, it was noted to be quite common there in 1983 (M. J. Oldham, personal communication).

Distichlis stricta **(Torr.) Rydb. var. *dentata* (Rbyd.) Hitchc.** *Middlesex County:* London Tp., Lot 25, Concession III, railroad ballast near switch at west end of Old Hyde Park C. N. R. station siding (UTM 733593, Map 40 1/14W St. Thomas), *D. McLeod 275-81* (lacking inflorescence), 25 October 1981 (DAO, UWO), and 116–82, 7 July 1982 (personal herbarium DM, TRTE).

The genus *Distichlis* (Salt Grass or Alkali Grass) was not reported for Ontario (Dore and McNeill 1980) or Michigan (Voss 1972). As the collection made in October was vegetative, characteristics in keys and descriptions of several manuals (Best et al. 1971; Gleason 1952; Hitchcock 1951; Hitchcock and Cronquist 1976; and Scoggan 1978) were used for tentative identification. Since flowering material collected in 1982 was entirely pistillate, this afforded confirmation of the initial determination.

If *Distichlis* were to be placed in Dore and McNeill's (1980) key to genera (p. 19), it would be included under the first part of couplet 3 — "spikelets unisexual". It could then be differentiated from *Zizania* (Wild Rice) and *Zea* (Corn), the only other genera with unisexual spikelets known to occur in Ontario, by its dioecious character; the other two being mooecious.

The name *Distichlis* alludes to the distichous or two-ranked leaves of two of the three species of this genus which are native to Canada and the United States (Hitchcock 1951; Scoggan 1978). Both *D. stricta* and *D. spicata* display this characteristic. These two species are also approximately the same size, and so could be easily confused. A third species, *D. texana,* is a larger plant of Texas and northern Mexico (Hitchcock 1951).

Distichlis stricta has longer spikelets, longer glumes, and looser panicles than *D. spicata.* The spikelets of the former approach 2.5 cm long, with lower glumes to 8 mm long, whereas spikelets and lower glumes of *D. spicata* are less than 1.5 cm and 3.5 mm, respectively. The leaves of *D. stricta* usually have

scabrous margins and sharp tips, whereas those of *D. spicata* usually have smooth margins and blunt tips. The dioecious nature of the genus creates identification problems, as staminate plants of the two species are difficult to distinguish. Staminate and pistillate plants of the same species have not always been recognized as such. Rydberg did not recognize the pistillate plant of *D. stricta* and named it *D. dentata,* thinking it to be a separate species (Hitchcock 1951).

Hitchcock and Cronquist (1976) recognize two varieties of *D. stricta.* The type variety, *Distichlis stricta* var. *stricta,* has pilose-hirsute upper leaf surfaces and pistillate paleas with less prominently dentate keels. The description of the other variety, *D. stricta* var. *dentata,* best fits our material, as the upper leaf surfaces are glabrous and the palea keels are obviously dentate.

The common names for *Distichlis,* Salt Grass or Alkali Grass, refer to the high salt content and/or the highly alkaline condition of the soil in which plants of the genus grow. Swink and Wilhelm (1979) report *Distichlis stricta* var. *dentata* as introduced to the Chicago Region from the western states. They note that there it is found in salty waste areas, including railroad yards and industrial sites. This agrees well with our occurrence in Ontario. The colony at London covers a 19 m × 1 m patch and completely dominates the limestone ballast along the railway (Fig. 1). The stout, scaly rhizomes have penetrated to a depth of 15 cm, making the grass very difficult for railroad personnel to control.

Eleven other vascular plants were found in proximity to the *Distichlis* population: *Agropyron repens* (Quack Grass), *Ambrosia artemisiifolia* (Common Ragweed), *Asclepias syriaca* (Common Milkweed), *Chenopodium album* (Lamb's-quarters), *Daucus carota* (Wild Carrot), *Linaria vulgaris* (Yellow Toadflax), *Melilotus alba* (White Sweet-clover), *Oenothera parviflora* (Small-flowered Evening-primrose), *Poa compressa* (Canada Blue Grass), *Solidago canadensis* (Canada Goldenrod), and *Vicia cracca* (Tufted Vetch). Four of these, *Agropyron repens, Asclepias syriaca, Melilotus alba* and *Poa compressa,* were among nine associates mentioned by Swink and Wilhelm (1979).

***Elymus elongatus* (Host) Runemark subsp. *ponticus* (Podp.) Melderis** (= *Elytrigia pontica* (Podp.) Holub; = *Agropyron elongatum* auct. amer., non (Host) Beauv.) *Kent County:* Harwich Tp., Concession II, north side of Highway 401, 2.1 miles east of Highway 40 interchange, about 7 miles east of Chatham, *A. A. Reznicek* (and S. A. Reznicek) *7086,* 20 September 1982 (DAO, MICH, TRTE), (sub *Agropyron elongatum*); 2.0 km W of Hwy. 21 interchange (to Ridgetown and Thamesville), S side of Hwy. 401, *M. J. Oldham 3600,* 20 April 1983 (CAN, MICH, TRTE), (sub *Agropyron elongatum*). *Elgin County:* North side of Hwy. 401, 2.0 km east of interchange 137, Hwy. 76 to West Lorne, about 2 km north of West Lorne, *M. J. Oldham 3525,* 22 November 1982 (MICH), (sub *Agropyron elongatum*); 25.0 km W of Elgin-Middlesex border, N side of Hwy. 401, 2 km E of Gulf Service Centre, 1 km W of Hwy. 8 interchange, *M. J. Oldham 3541,* 1 April 1983 (DAO, MICH, TRTE), (sub *Agropyron elongatum*); 0.7 km E of Iona interchange (Hwy. 14), 3 km W of railroad bridge, 1.8 km W of Lawrence Station Road overpass, S side of Hwy. 401, *M. J. Oldham 3601,* 20 April 1983 (CAN, TRTE), (sub *Agropyron elongatum*). *Essex County:* Maidstone Tp., 1 km S of Pike Creek (town), N side of Hwy. 2, 0.4 km E of bridge over Pike Creek (watercourse), roadside adjacent to Hiram Walker & Sons warehouse, UTM 486845, *M. J. Oldham 3543,* 1 April 1983 (CAN, MICH, TRTE), (sub *Agropyron elongatum*).

FIGURE 1. *Distichlis stricta* (Torr.) Rydb. var. *dentata* (Rydb.) Hitchc. in railway ballast at London, Ontario (photograph by D. McLeod).

According to the keys in Melderis (1980) our specimens of Wild Rye are *Elymus elongatus* subsp. *ponticus*. Recent studies have shown that there are two taxa in Europe, a decaploid (*Elymus elongatus* subsp. *ponticus*) and a diploid (*Elymus elongatus* subsp. *elongatus*), which should be considered species (Dvorak 1981; Dewey 1983). Introduced material in the United States has been called *Agropyron elongatum*. According to Dewey (1983) all North American material is decaploid and should be called *Elytrigia pontica*.

Dore and McNeill (1980) recognized that delimitation of the genera *Agropyron, Elymus* and *Elytrigia* was problematic. *Elymus elongatus* subsp. *ponticus* has spikelets solitary at each joint of the rachis so would be included in *Agropyron* in their work. The placement in *Elymus* is based on the treatment by Melderis (1980).

If our specimens were identified with the key in Dore and McNeill (1980), they would run the couplet distinguishing *Agropyron caninum* and *A. trachycaulum*. However, the anthers of our specimens are 4–7 mm long, much larger than ther 2–3 mm anthers of *A. caninum,* and the glumes have 7–9 nerves, more like those on glumes of *A. trachycaulum*. The ciliate sheaths and spikelets 17–19 mm long with 8–12 florets agree with the description of *Elymus elongatus* subsp. *ponticus* in Melderis (1980).

Elymus elongatus subsp. *ponticus* is reported to occur in dry or saline habitats in southeastern Europe (Melderis 1980). It is otherwise known in North America from the western United States (specimens from Montana and New Mexico filed under *Agropyron elongatum* at MICH). The closely related *Elymus elongatus* subsp. *elongatus* occurs in maritime habitats in Europe (Tutin et al.) and would perhaps be less suitable for colonizing the interior of North America. It is interesting to note that *E. elongatus* subsp. *ponticus* is at least a facultative halophyte (A. A. Reznicek, personal communication). This ability to persist in saline conditions along Highway 401 is probably important, although perhaps not for the populations in the western United States, where roads are not commonly salted.

***Poa sylvestris* Gray** *Kent Count:* Rondeau Provincial Park: *J. Laudenbach,* 22 June 1975 (TRTE); Rondeau Trail, *M. Barkworth 1963* and *1964,* 19 June 1977 (DAO); south of Bennett Road, *J. M. Webber 4351,* 18 June 1982 (CAN, DAO, MICH, TRTE, UWO).

Poa sylvestris (a native Blue Grass) superficially resembles *Poa pratensis*. Unlike that species, *P. sylvestris* is not rhizomatous; the keel of the lemma is hairy nearly to the end of the green portion, rather than hairy on the basal 2/3; and the intermediate nerves of the lemma are usually hairy rather than glabrous. *Poa sylvestris* is readily identified in Voss (1972). If Dore and McNeill (1980) is used, specimens of *P. sylvestris* key to the *P. alsodes - P. nemoralis - P. glaucantha - P. interior* section. *Poa sylvestris* most closely resembles *P. alsodes* (Woodland Poa), but differs from it in the distinctive hairy keel of the lemma.

Poa sylvestris is a widespread species of rich, mature, deciduous forests in the northeastern United States (Hitchcock 1951). Rondeau Park is the only known Ontario and Canadian locality for this grass (Reznicek 1984). It was found by J. M. W. in 1975 and in 1982 on hummocks in a hardwood swamp with 90% canopy cover dominated by *Acer saccharinum* (Silver Maple), *Liriodendron tulipifera* (Tulip Tree), *Tilia americana* (Basswood), *Fraxinus pennsylvanica* (Green Ash), *Acer rubrum* (Red Maple), and *Ostrya virginiana* (Hop Hornbeam). Saplings of *Ulmus americana* (White Elm) and the shrub *Lindera benzoin* (Spicebush) were important understory components. The hummocks on which the *Poa sylvestris* occurred had all resulted from tip-overs. These were ¼ to ½ m above standing water and supported communities of low herbaceous species. On these drier, island microhabitats were *Carex pensylvanica* (Sedge), *Amphicarpa bracteata* (Hog Peanut), *Maianthemum canadense* (Canada Mayflower), *Carex convoluta* (Sedge), *Sphenopholis intermedia* (Slender Wedge Grass), *Galium triflorum* (Sweet-scented Bedstraw), *Poa pratensis* (Kentucky Blue Grass), *Prunella vulgaris* (Heal-all), *Ranunculus abortivus* (Small-flowered Buttercup), *R. recurvatus* (a Buttercup), *Parthenocissus inserta* (Virginia Creeper), *Thalictrum dioicum* (Early Meadowrue), *Arisaema triphyllum* (Jack-in-the-pulpit), and *Carex gracillima* (Sedge). The hummocks had 10 to 30% moss cover. Surrounding swampy habitats, less attractive to most hikers and botanists, may account for the fact that *Poa sylvestris* was overlooked at Rondeau Park.

Although *Poa sylvestris* was searched for in other rich woodland habitats in Rondeau Park in 1982, it was found only at Bennett Road. However, M. Barkworth collected this species in a beech-maple woods along Rondeau Trail in 1977.

***Stipa comata* Trin. & Rupr.** *Simcoe County:* Medonte Tp.: 13½ miles north of Barrie, just east of the 4th Line between the Ingram Road and the Coldwater River, *R. S. W. Bobbette 6312,* 9 July 1979 (personal herbarium RSWB); Lot 6, Concession V, 13½ miles north of Barrie, *A. A. Reznicek* (S. A. Reznicek and J. M. Webber) *5127,* 28 July 1979 (personal herbarium AAR).

This grass, aptly named Needle-and-thread, has a number of spikelet characters which are intermediate in size between *Stipa avenacea* (Black-seed Needle-

grass) and the larger species *S. spartea* (Porcupine Grass). It is readily identified in Dore and McNeill (1980), who note that the only Ontario report, from Squirrel Island, Lambton County (Dodge 1914), was based on a misidentified specimen of *S. spartea* (Gaiser and Moore 1966). Based on that erroneous report, the range of *S. comata* was reported to extend to southern Ontario (Fernald 1950).

According to the distribution map in Barkworth (1978), *Stipa comata* occurs from the Yukon south to New Mexico, and east to southern Manitoba, northern Michigan and northern Indiana. Weber (1976) reports that this species is the most common member of the genus *Stipa* in Colorado, where it occurs "from plains to upper montane".

Our record of *Stipa comata* was from a dense colony of about 50 square metres. It occurred with *Danthonia spicata* (Poverty Oat Grass) on a dry, sandy opening at the crest of a steep valley. Located in the Copeland Forest Resources Management Area (Ontario Ministry of Natural Resources), this locality has a history of disturbance due to lumbering activities and it is likely that *S. comata* is introduced here (Bobbette and Webber. 1979. Botanical inventory of the Copeland Forest Resources Management Area. Ontario Ministry of Natural Resources, Huronia District Office. Midhurst. 156 pp.).

While proximity to the transcontinental C. P. R. on the other side of the valley does suggest a possibility that *S. comata* is an historical introduction, a second possibility exists that should be kept in mind. Copeland Forest is centrally located in what was once the main territory of the agricultural Huron Indians. These native Canadians lived in what is now the northern part of Simcoe County from at least the early 1400's to 1650. They conducted extensive clearing as part of their agricultural activities. Champlain reported that northern Simcoe was ". . . very fine, mostly cleared, with many hills and several streams . . .", while Sagard said "The country is full of fine hills, open fields, very beautiful broad meadows bearing excellent hay . . ." (both quotes from Heidenreich 1971). With soil exhaustion requiring new clearing every 5 to 15 years, and tree regeneration taking at least 2–3 times as long, up to 20 235 hectares (50 000 acres) out of the total 200 000 acres (or so) of Huronia could have been either corn fields or "beautiful broad meadows" by 1615, when Champlain visited the area (Bobbette and Webber 1979). The "excellent hay" that grew in these extensive fields would have been naturally derived, and it is in this context that we could expect native North American grasses now rare here, such as *S. comata,* to have flourished.

Acknowledgments

We thank E. G. Voss for confirming the identity of a specimen of *Poa sylvestris* and P. M. Catling and J. McNeill for identifying X *Agrohordeum macounii.* A. A. Reznicek provided us with information about the first Canadian specimens of *Elymus elongatus* subsp. *ponticus,* M. J. Oldham provided additional records of this species as well as *Bromus squarrosus* and P. M. Catling supplied collection data for a record of *Anthoxanthum odoratum.* We are grateful for correspondence with W. G. Dore and our appreciation is extended to A. A. Reznicek, P. W. Ball, S. G. Aiken and an anonymous reviewer for commenting on previous drafts of the manuscript. The *Stipa comata* record was discovered during contract research for the Ontario Ministry of Natural Resources, Huronia District.

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Received 3 October 1983
Accepted 28 August 1984

A Southward Return Migration of Painted Lady Butterflies, *Vanessa cardui*, over Southern Alberta in the Fall of 1983, and Biometeorological Aspects of their Outbreaks into North America and Europe

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Myres, M. T. 1985. A southward return migration of Painted Lady butterflies, *Vanessa cardui*, over southern Alberta in the fall of 1983, and biometeorological aspects of their outbreaks into North America and Europe. Canadian Field-Naturalist 99(2): 147–155.

Southward fall movements of Painted Lady butterflies, *Vanessa cardui*, have only rarely been documented in North America. From 13 August to 7 September 1983, Painted Ladies were reported over a wide area of southern Alberta from the plains to 7500 feet (2286 m) in the Rocky Mountains, and as far north as Red Deer. At Calgary the direction of movement was most commonly SSW-SW. It is argued that Painted Ladies show strong seasonal migratory orientations, but that early arrival in Alberta in May (e.g. in 1901, 1973 and 1979) presupposes more favourable wind conditions, and longer distances travelled by each generation of butterflies, than in years when they arrive later (such as 1983) or not at all. Estimates indicate that tens of millions of Canadian-bred Painted Ladies were migrating southwards across Alberta in August 1983, perhaps as many as 100 million. A link between winter precipitation in southwestern desert regions and some El Niño warm water intrusion events in the eastern Pacific Ocean suggests that these, and other air-ocean teleconnections that produce similar effects, are the ultimate cause of major Painted Lady outbreaks from desert source areas, not only into North America but also from North Africa into Europe.

Key Words: return migration, Painted Lady, *Vanessa cardui*, Alberta, radar, biometeorology, air-ocean teleconnections, El Niño.

The Painted Lady, *Vanessa cardui*, is one of the most widely distributed species of butterfly in the world. It is notable for its long-distance movements, which are most conspicuous in the spring or early summer months. It has been said that "the only source of immigration for Painted Lady butterflies in the United States is from Western Mexico" (Williams 1958, p. 106). Migration is probably "a normal seasonal aspect of the biology" of the Painted Lady in California (Shapiro 1980), even though thin migrations are often not recognized as such. Though 'migration' is not necessarily the most accurate or desirable term (Baker 1969), it is employed because it is the one most frequently used to describe movements of the Painted Lady. In certain years the movements north from the source areas in the deserts of Mexico might more appropriately be described as 'outbreaks', and this term will be used for the movements in such years. One outbreak, into California in 1924, "was believed to contain 3,000 million" butterflies (Williams 1958).

A study by Williams et al. (1942) produced the remarkable findings that in the 74 years from 1865-1938 there were 40 years (54%) in which Painted Ladies were rare in both North America and Europe and 13 years (18%) when they were abundant simultaneously on both continents. In 21 of the 74 years (28%) Painted Ladies were either common in Europe but not simultaneously in North America (14 years), or *vice versa* (7 years)(Williams 1958). The reasons for the similar situation in the two regions in 72% of the years were not determined by Williams and his colleagues, but likely explanations are considered later in this paper.

In Arizona, and in California (Tilden 1962), Painted Ladies probably occur every year, at least in small numbers, perhaps local breeding populations. In the Great Basin there were northward flights through Utah in 1924, 1930, 1931, 1935, 1941 (Woodbury et al. 1942), 1945 (Sugden et al. 1947) and 1973 (Bird 1973), and probably other years between 1945 and 1983. In 1973 Painted Ladies were seen from Nevada and Idaho to Colorado (Bird 1973; Brown 1974; Giuliani 1977). In the Pacific coast states Painted Ladies were especially abundant in California in 1901, 1924, 1926, 1941, 1945 (Abbott 1950), 1949 (Abbott 1951), 1958 (Abbott 1959) and 1973 (Giuliani 1977), and probably some additional years between 1958 and 1983. Guiliani (1977) mentions 1968 as having been another migration year. Farther north, it is on record that Painted Ladies occurred in Oregon in 1958 (Tilden 1962) and in Washington State in 1966 and 1973 (Pyle 1974). The North American northbound migrations were also discussed by Williams (1970), but it is clear from comparing Utah and Cali-

fornia (above) that outbreaks do not always reach both states in the same year; this might perhaps be due to different synoptic weather patterns in different years. The other point to make is that the most spectacular outbreaks of Painted Ladies were in 1901, 1924, 1941, 1958, 1973 and 1983.

Painted Ladies do not reach western Canada every year, but perhaps in a majority there are low numbers which go unremarked. However, once or twice in each decade (as in the United States) they are reported in much larger numbers. They reached Alberta in considerable numbers in 1900 and 1901 (Wolley Dod 1901a, 1901b), Saskatchewan in 1952 (Hooper 1973), Alberta in 1958 (Agriculture Canada 1973), Manitoba in 1967 (Masters 1972), British Columbia, Alberta and Saskatchewan in 1973 (Bird 1973; Agriculture Canada 1973) and Alberta in 1979 (Thormin et al. 1980; Kondla 1981). Undoubtedly this is an incomplete listing.

In Eurasia southward movement has been recorded in the fall, but apparently there has been "only slight evidence of any such flights in North America" although "there are one or two records suggesting return flights in the autumn" (Williams 1958, pp. 27 and 139). A return migration in California from August to October 1979 was described by Shapiro (1980). This paper describes a return movement southwards that took place across Alberta in August and early September 1983.

Circumstances and Methods

On days when movement of Painted Ladies was detected, from 17 August to 1 September 1983, a number of 10-minute counts were made. The balcony of my house made an excellent observation post because it is oriented WNW-ESE, and so faces NNE, which was the direction from which the butterflies were coming. It is located on Sunset Avenue, on the south side of the Bow River in the Upper Scarboro (Shaganappi) district of southwest Calgary. The house is part way up a steep north-facing slope, and there is a clear view towards the downtown skyscrapers, with the old Sunalta school in the foreground. The field of view ('window') within which I could see approaching butterflies was about 50 metres wide, with trees on either side. Against a background of dark green vegetation, the Painted Ladies were not easy to see head-on, but they were easy to see sideways-on.

During the three-week period of the movements, in August and early September 1983, the weather was rather consistently sunny. Winds ranged from still or very light up to moderate breezes by day and were from SSW-W in direction.

In conversations with acquaintances it became apparent that a number of other people had also noticed large numbers of butterflies at a variety of widely scattered locations across southern Alberta during the same period. I assembled a number of these observations, which are presented in Table I, but undoubtedly many more could be added. Only a few observers, unfortunately, had noticed that the butterflies that they saw were actually moving in a particular direction. Those who had mostly recalled it by reference to the direction of movement across roads along which they had been driving.

It is necessary to state that the term 'butterflies' was as far as many of my informants (Table 1) could identify what they had seen, but it is quite evident from my own observations that where the butterflies were numerous enough for notice from a moving car over some distance of highway, the Painted Lady was the species involved. Two of my informants referred to the butterflies as "monarchs", either because of themselves being immigrants to western Canada or as a folk-memory among country people in southern Alberta whose forbears came from eastern Canada.

Results

The Northward Migration in 1983

Painted Ladies usually arrive in Alberta in late May: as early as 15-16 May in 1973 (Bird 1973), 22 May in 1977, 23 May in 1979 (Thormin et al. 1980) and before 25 May in 1901 (Wolley Dod 1901b). In 1983, however, northward migration into Alberta seems to have been later than usual because Painted Ladies were not at all numerous before the last ten days of June (D. Elphinstone and H. Pinel, personal communications). It was apparently a gradual or extended movement and the butterflies were not particularly spectacular. Nevertheless, there was a large emergence of adults in late August (J.R. Byers, personal communication) and, allowing 50 days from egg-laying to adult emergence, eggs must have been laid in late June or early July. It seems likely, also, that whatever the numbers involved in the June arrival, the survival rate from egg to adult was, perhaps unusually for this latitude, high in Alberta in 1983.

If return flights occur, there will be a date after which northward movement disappears and the direction is reversed. Williams (1951) identified a number of species of migrant butterflies for which southward movements in the fall had been recorded in Britain. For several such species, including the Painted Lady, Baker (1969) has shown that direction reversal occurs in mid-late August in Britain, being earlier farther north. Britain and Alberta are at the same range of latitudes, so the occurrence of southward rather than northward migration in late August here is to be expected if there has been an earlier arrival of the species.

TABLE 1. Reports of large numbers of butterflies in southern Alberta, fall 1983.

Date	Location	Remarks (Observer)
13 August	Calgary	text, and Table 2 (M. T. Myres).
14 August	between Calgary and Strathmore	crossing Trans-Canada Highway from north to south at ca. 0930 (Moray J. Lewis).
15 August	between Lethbridge and Fort Macleod	crossing Highway No. 3 from north to south in a band ca. 5 km wide at ca. 1500 during 5–10 min of driving time (John A. Vandergiessen).
15 August	Wildlife Reserve of Western Canada, Cochrane	2-3 at a time moving southwestward, for a total of ca. 300 from 1600–1800 (Stuart Johnston).
16 August	Wildlife Reserve of Western Canada, Cochrane	a steady stream continued southwestwards in the morning, before 1100 (S. Johnston).
17 August	Wildlife Reserve of Western Canada, Cochrane	butterflies were being hit by cars on the road to Cochrane (S. Johnston).
17 August	Calgary	crossing roads from Bow River to airport (about 20 km); also see Table 2 (M. T. Myres).
about 17 August	between Calgary and Lacombe	crossing Highway 2 from east to west (Peter Heyes).
17 August	Waterton Lakes National Park	southward movement of numerous Painted Ladies along ridge at ca. 7500 feet (2286 m) between Mt Lineham and Mt Rowe (J. R. Byers).
(mid-August)	Sundre	Painted Ladies seen (Allan H. Legge).
19 August	en route from Calgary, via Brooks, to Vauxhall	along parts of the Trans-Canada Highway and Highway 36 (Sheila Cheeseman).
20 August	Calgary (Lowery Gardens natural area beside Bow River, west of Crowchild Trail	several hectares of thistles covered in Painted Ladies; this is not far from the site where counts were made for Table 2 (Moray J. Lewis).
20 August	en route from Calgary to Radium, British Columbia	Painted Ladies seen along Trans-Canada Highway as far west as Banff town-site (Gordon Pritchard).
20 August	Kananaskis River valley (Ribbon Creek Trail)	lots in middle of day (Herbert I. Rosenberg).
21 August	Waterton Lakes National Park	butterflies seen (Sheila Cheeseman).
22 August	en route from Edmonton to Calgary	butterflies were found all over a car grill on arrival in Calgary (V. Robinson *per* Anita Soudeen).
22 August	Trans-Canada Highway	thousands going south across highway in the Rocky Mountain foothills; peak at Canmore where they were also settling on thistles; none seen beyond Lake Louise (Robert J. Cannings).
23 August	Burstall Lakes and meadows below Burstall Pass, Kananaskis Provincial Park (see map in Kondla and Bird 1979)	very abundant at about 7000 feet (2137 m) near the Continental Divide west of the Smith-Dorrien Highway (Michael H. Benn).
26 August	Calgary	text, and Table 2 (M. T. Myres).
27 August	Calgary	text, and Table 2 (M. T. Myres).
27 August	Wildlife Reserve of Western Canada, Cochrane	lots migrating southwestwards across the Grand Valley road at 1130 (Stuart Johnston).
28 August	en route from Calgary to Edmonton	at least as far north as Red Deer (Sheila Cheeseman).
29 August	from Cluny to Calgary	along Trans-Canada Highway (M. Robinson *per* Anita Soudeen).
29 August	Calgary	Table 2 (M. T. Myres).
30 August	Calgary	Table 2 (M. T. Myres).
1 September	Calgary	Table 2 (M. T. Myres).
1 September	for 30 km west from Calgary	about mid-day, lots of dead butterflies on the Trans-Canada Highway, and about one per minute seen crossing it from north to south (total ca. 20) (Donna Anderson).
6-7 September	Upper Kananaskis River valley and up to North Kananaskis Pass at about 7000 feet (2137 m)	thousands of Painted Ladies, but no movement seen; it snowed above 5500 feet (1676 m) on the night of September 6-7 (Moray J. Lewis).

TABLE 2. Ten-minute counts of Painted Ladies migrating at Calgary, fall 1983.

Date	Times (MDT)	Direction	Numbers/10 min	Number/min	Mean
13 August	(p.m.)	(SW)	(ca. 30 in 30 min)	(1.0)	—
17 August	1520–1530	SW	22	2.2	1.45
	1535–1545	"	11	1.1	
	1550–1600	"	12	1.2	
	1605–1615	"	13	1.3	
	(1645)	"	(42 in 2 min)	(21.0)	
	(1830)	"	(movement continuing)	—	
26 August	1325–1335	SSW(SSE-SW)	40	4.0	3.45
	1340–1350	"	56	5.6	
	1355–1405	"	25	2.5	
	1410–1420	"	17	1.7	
27 August	1145–1155	—	3	0.3	1.1
	1355–1405	SE-SSE	14	1.4	
	1410–1420	"	12	1.2	
	1640–1650	SSE	13	1.3	
	1725–1735	"	12	1.2	
29 August	1205–1215	SE-SW	5	0.5	0.25
	1555–1605	—	0	0.0	
30 August	1210–1220	SSW	135	13.5	6.56
	1225–1235	S-SSW	60	6.0	
	1240–1250	"	65	6.5	
	1255–1305	"	65	6.5	
	1710-1720	"	3	0.3	
1 September	1345–1355	SW	40	4.0	2.6
	1415–1425	"	20	2.0	
	1430–1440	"	19	1.9	

Personal observations in August 1983

I first noticed a movement of butterflies from the balcony of my house on the afternoon of 13 August. Several were seen flying in the same southwestward direction. It was sunny and warm, with little or only light wind at ground level.

On 17 August I drove to the Calgary airport in the early afternoon. The weather was similar to that four days earlier. Overhead the wind was westerly. I saw butterflies crossing the road in front of me, all the way from the Bow River north along Crowchild Trail to the university, and along John Laurie and McKnight Boulevards, a distance of at least 15 km. At the turning on to Barlow Trail, I began a count. This section of road to the airport terminal is just over 4 km long and it took 5 minutes (1330-1335) to drive it, during which I saw 52 butterflies. On the return journey (1415-1420), I counted 75 butterflies crossing the road moving SW. Had I continued to drive through them for an hour I might, therefore, have seen about 800 butterflies. In addition to the flying insects, there were more than a dozen dead on the road. Back at my house, the SW migration was again visible from the balcony (Table 2).

On 26 August I noticed Painted Ladies flying over the Brentwood Mall parking lot at about 1300 hours. Driving south along Crowchild Trail north of the Bow River, I saw more butterflies crossing the road flying about southwestward. A series of four 10-minute counts from the balcony between 1325 and 1420 hours revealed a movement at least 3x heavier than on 17 August (Table 2). It continued for several hours, and was seen later in the afternoon along 17th Avenue, S.W. as far as 45th Street S.W. On 27 August a mean of 1.3/minute was travelling SE-SSE at 1355-1420 hours. This movement continued until at least 1735, although the direction was SSE in the late afternoon.

On 28 August no movement was seen, perhaps because there had been thunderstorms in the early morning. On 29-30 August and 1 September I saw Painted Ladies crossing Crowchild Trail between the university and my house in the early afternoons, and I made counts from the balcony (Table 2).

Extent of the movement

What the reports in Table 1 show is that conspicuous numbers of butterflies were being seen by many people, particularly when driving along main highways (especially the Trans-Canada Highway and Highway No. 2 between Calgary and Edmonton) on 14-15, 17, 19-20, 22 and 28-29 August and 1 September, as well as at particular locations, especially

Calgary, Cochrane and Kananaskis Provincial Park. The geographical extent of the phenomenon was at least from Brooks and Vauxhall in the east to Sundre, Banff and Kananaskis Provincial Park in the west, and from at least as far north as Red Deer or Lacombe to as far south as Lethbridge and Waterton Lakes National Park. There is also a report that Painted Ladies were seen as far north as the Columbia Icefields in the Rocky Mountains (*B. C. Naturalist* 21(4): 21). In Alberta, therefore, Painted Ladies were evidently abundant over a region of, at least, several hundred kilometers in diameter. Byers et al. (in press) report that there was substantial contamination of the harvest of mustard (and also canola) seed in the prairie provinces in 1983 by frass from the caterpillars of Painted Lady butterflies that fed on thistles in these crops.

Density of movement at Calgary

The results of the 10-minute counts from the balcony at Sunset Avenue are presented in Table 2. Painted Ladies were most dense during a 2-minute count at 1645 on 17 August, when the rate was 21/minute (one every three seconds) for a short time. This occurred just as a breeze began to develop, so this may have had the effect of aggregating the butterflies in a particular pocket of air. The highest rate for a full 10-minute count was of 13.5/minute at mid-day on 30 August, but this was not sustained and for the rest of the hour the counts were around 6.5/minute. Altogether, during the period of the movements the means of several counts on days when Painted Ladies were seen ranged from about one butterfly per minute up to as high as one every 10 seconds.

Direction of the movement

The direction of movement varied slightly from day to day, but centered on SSW or SW. On 27 August the direction was SE-SSE or SE, rather than west of south. The range of directions was greatest on 26 and 29 August (SE or SSE round to SW), while on other days it was quite narrow (Table 2).

Discussion

Condition of the butterflies

The insects that I saw were fresh, i.e. dark, brightly-coloured and whole. I do not recall seeing any that were pale or obviously worn or tattered. Their flight was fast and direct. For these reasons, and because Byers et al. (in press) report that a large generation emerged in August on the Canadian prairies, I have no doubt that they were Canadian-bred, not recently arrived migrants from farther south.

Detectability

It was chance that I selected to make counts for 10 minutes at a time, but I later discovered that Williams (1958) had suggested this. He also presented a 7-point scale for registering the density of an insect migration (Williams 1958, pp. 103-104). Densities I-III are called "extremely thin", "very thin" and "thin" migrations. "Extremely thin" (2-10 insects crossing a 50 yards or 45.7 m front in 10 minutes) was defined as "only seen by careful watch by an expert"; "very thin (11-50 insects/10 min) as "should be seen by any careful watcher"; "thin" (50-230 insects/10 min) as "should be obvious to any competent field naturalist." Each class is 4-5 times larger than the previous one. "Thin" densities produce migrations of 10 000 – 50 000 butterflies "per mile front per hour" according to Williams. Density IV (233-1080 insects/10 min) was defined as "obvious to any normal person", and it results in about 225 000 insects crossing a one mile (1.6 km) front in one hour.

It is evident from Table 2 that what I saw in Calgary was in the range of Williams' Densities I-III, and was in agreement with his view that these are not usually detectable by the general public. Indeed, I wrote at the time that I did not think that the casual observer would notice the movement of Painted Ladies if it involved only one butterfly at 60 second intervals. In fact, 1-2 minutes might pass when no butterfly was recorded, and the insects tended to be clustered with two or more in fairly quick succession, followed by short periods when none were seen. Two or more butterflies in sight together seem to be much more noticeable than one, and when their movement in a particular direction is followed within a short time (perhaps less than two minutes) by two or more others travelling in the same direction, we seem to detect this pattern more easily. Thus a rate of 2.2/minute is fairly conspicuous, while 1.1/minute is probably not. This is a function of the human attention span and restlessness.

It is also certain that many people who saw the Painted Ladies in 1983 in Alberta attached little or no significance to what they had seen; hopefully, this paper may lead to additional observations being published. In particular, I do not know whether the movement occurred also in Saskatchewan. In British Columbia Painted Ladies were abundant in Kootenay National Park in eastern British Columbia (*B. C. Naturalist* 21(4): 21) which, although no dates were given, is not surprising in view of the Alberta Rocky Mountain records in Table 1.

Size of the movement

One can use exact transect or point counts to estimate the total passage. If movement across Calgary took place for only 5 hours and only over a 20 km front, at the rate of 1.0/min and with the insects spaced every 50 m apart along the front, then the number of migrating insects on 17 August 1983 would

have been 120 000 — a huge figure although the movement was only just detectable most of the time. On 26 August the mean rate from 1325-1420 was 3.45 butterflies/minute (207/hour) and, using the same calculations, the number of migrating insects would have been 414 000. On 30 August the mean rate of movement was about 6.5/min for at least one hour; if the movement had taken place over a 20 km front for only 2½ hours, the number of butterflies would, again, have totalled almost half a million.

Several millions of butterflies probably traversed the Calgary district on 26 and 30 August 1983. It is likely that on all these days the movements were in fact along a front several times longer than the 20 km employed in the above examples. Considering the duration of the passage (Table 1), I estimate conservatively that tens of millions of Painted Ladies must have migrated southwards across southern Alberta in August and early September 1983. The true figure could be over 100 million.

Behaviour

A characteristic behaviour pattern in the Painted Lady is that the butterflies "tend to fly over obstacles rather than round them" (Tilden 1962), which strongly suggests oriented behaviour. Many of the Painted Ladies seen from the balcony started to rise when they were only mid-way across the lawn towards the house. They seemed to be detecting the dark shadow that it made horizontally ahead of them and to be avoiding it, thereby remaining in visual contact with the sun. On 26 August they likewise rose up the height of some poplar trees in order to get over them.

On 26 August it was sunny and warm, but the sky was hazy. The wind was light and from the SSW. Many of the Painted Ladies seen from the balcony were flying much higher than I had seen them doing before, to the limit of visibility, so that many or most could have been too high to be seen. They were moving S-SW, but engaged in side-to-side fluttering (slipping from SE to SW in direction and back again quite quickly), and quite often two butterflies were travelling together with one pursuing another, while many were also gliding on open wings to a noticeable extent. On 30 August it was also fine and hazy, but with a SSW breeze, and I again noted that the butterflies were flying high as they crossed over the house towards the S-SSW; many were travelling together and fluttering around each other. On most other occasions, however, the flight seen from the balcony was remarkably straight and direct.

Rocky Mountain records

Painted Ladies have been "found late in the fall at high elevations in the mountains of the western United States" (Tilden 1962) and even recorded "passing to the south-east at an altitude of 17,000 feet" (5200 m) in August in northwestern Pakistan (Williams 1958, p. 25). So, the occurrence of Painted Ladies at over 7000 feet (2137 m) in the Rocky Mountains of Alberta, in Waterton Lakes National Park on 17 August, below Burstall Pass on 23 August and near North Kananaskis Pass on 6-7 September (both in Kananaskis Provincial Park), is not unexpected. What is of interest is that, to reach these locations, the butterflies must have flown over the forested zones of the Eastern Slopes. Furthermore, the Rocky Mountains are here oriented about NW-SE and so were almost at right angles to the observed direction of the migration across southern Alberta. It seems that the butterflies were flying in an oriented direction towards the mountains which lay in their path and had reached these considerable altitudes on the occasions when they were seen. Just as they must cross numerous high mountain ranges in the western United States during their northward migrations, so we might expect them to be capable of crossing the Rocky Mountains of Alberta in a southwesterly direction, though doing so as late as 6 September (Table 1) has considerable risks at this latitude.

Orientation and height of migration

The mechanisms by which butterflies orient themselves while on migration are still surprisingly controversial (Wehner 1984). Abbott (1951) analyzed the movements of Painted Ladies in spring northwards through California in relation to the observation that they often fly in to the wind, which is primarily from the north at this season. The Painted Lady is a strong flyer and evidently adapted to incurring this energetic expense when required, even flying into "near-gale" force winds on occasion (Giuliani 1977) and in heavy rain (Tilden 1962). But the idea that wind plays a role in determining the primary orientation of a strongly migratory species (Tilden 1962) seems implausible.

During most of the period when the Painted Lady migration was taking place across southern Alberta in August-September 1983 the wind was southwesterly, although it was often only a light wind. The observed flight of the butterflies therefore happened usually to be into wind. However, this southerly movement persisted for nearly a month in a variety of circumstances, and ranged from SE-SW (being sometimes across the wind). This in itself suggests that the direction of flight was determined by the migratory behaviour pattern at that season and/or in that generation of the insects, and was not merely a fortuitous (southward) response to wind direction.

There is some evidence that the direction of movement of migrating Painted Ladies changes during the day in the direction that would be expected if they were orienting by the sun without compensation for

its movement across the sky (Baker 1968). I did not notice this but, if it is so, the direction in the mornings would have been more southeasterly than southwesterly. In fact, I rarely saw any significant number of Painted Ladies from the balcony before mid-day. At the time I thought that this might be because the day was not yet hot but, in retrospect, it could have been because they were flying between SE and S across the wind at a greater height. If their direction of orientation gradually became more into wind as the sun moved across the sky after mid-day they might thus have begun to fly closer to the ground (alternatively, the southwesterly breezes may not have strengthened until the afternoons).

Bird (1973) noted that on 16-17 May 1973 "most of the Alberta sightings were of female butterflies flying downwind in a northeasterly direction." Considerable assisted passage is probably necessary to explain how large numbers of Painted Ladies manage to travel so far north as Alberta so early in the season. If a Painted Lady outbreak begins in Mexico in late February, there could be (at most) only one intervening brood before butterflies arrive in Alberta in mid-late May. In years when Painted Ladies reach Alberta late, in June or July, there may have been two or three intermediate generations produced en route.

As noted earlier, there were indications that on days when the wind was negligible at Calgary many of the Painted Ladies may well have been migrating at elevations beyond the limits of visibility from the ground. There were a number of days when I did not notice any migration from my vantage point, although Painted Ladies were seen elsewhere by other observers, so they may have been flying too high over my house on these occasions.

Observations in the literature of Painted Ladies flying into wind at ground level are probably due only to the butterflies flying lower when there is a wind from the direction in which they are oriented. It was found years ago, by means of radar, that while some bird migration might be seen in strong opposing winds, movements in light or following winds were (though invisible) often much heavier; in other words, what is observed with the naked eye can give a false estimate of the relative densities of movements in a particular direction in winds of different direction and strength. While apparently heavy movements of Painted Ladies may be seen when there are opposing winds, even heavier oriented movements in the same seasonal direction may well be taking place, apparently at lower density or even largely out of view, when the winds do not oppose the migrants and they are flying higher.

Schaefer (1970, 1976) has tracked butterfly movements during a study of migrating desert locusts, *Schistocerca gregaria*, with a mobile 3 cm radar in the Sahara. Using the same technique, it should be possible to track Painted Ladies and establish whether or not they migrate in a largely different manner from that so far described in the literature (e.g. whether they may be flying at a greater height, assisted by the wind and/or even at night), and during an outbreak they would be relatively easy to identify on the radar.

It has been said that "a population of airborne insects must be envisaged as a biometeorological system" (Rainey 1974). As will be noted later, the conditions under which desert locusts breed and the conditions prevailing prior to and during outbreaks by Painted Ladies appear not greatly dissimilar. For the locusts (1) the breeding areas are "characterized by scanty and erratic rainfall" and "the migrations of swarms commonly takes them out of areas in which the seasonal rains are finishing and into areas in which the seasonal rains are beginning", and (2) zones of wind convergence are a "condition for the production of rain" and thus "a mechanism is provided for the fact that areas and seasons of breeding by the desert locust are characteristically areas and seasons of rainfall" (Rainey 1974). Since in outbreak years, movement of Painted Ladies is usually seen in April and May almost simultaneously over a wide range of latitudes in the western United States, the butterflies arriving in Alberta in May may well have emerged as far south as the deserts of Mexico or Arizona and travelled north very rapidly unhindered by opposing winds. This suggests the desirability of examining the synoptic weather charts for April and May over a wide area of the Cordilleran states (e.g. Arizona, Nevada, Utah and Idaho) during future Painted Lady outbreaks to determine the overall wind patterns at the time of the movements.

Determinants of the size of return movements

Whether or not return migration towards Mexico is necessary for the maintenance of the source populations of the Painted Lady, it would not be the earlier but rather the later generations of an annual sequence during an outbreak that would be most likely to perform such southward migrations. The butterflies may move northward after emergence and before egg laying either slowly or more rapidly. The last adult emergence in the series may occur in Arizona, Utah, Nevada or California in some years, but in northern states or western Canada in others. Painted Ladies are often abundant in September at high elevations in California and Arizona (Tilden 1962). During 1979 (a year when they reached Alberta), a southward return movement was recorded in California that included females laying eggs there in late August (Shapiro 1980). The farther north that breeding occurs, the stronger and more urgent the tendency may be for the

later generations emerging in August to make the return migration. Excepted would be the offspring of Alberta May arrivals, which would continue on in July to the Northwest Territories where conditions would be unfavourable for survival or successful breeding.

Canadian-bred Painted Ladies might, therefore, be numerous enough to exhibit evidence of an urgent return migration in late summer most often in those years when (as in 1983) their parents had arrived late and in large enough numbers to lay many eggs. Even then it might only be noticed (1) when conditions in mid-summer are favourable for a high survival rate from egg to emergent adult (as seems to have happened in 1983) and (2) when the return movement is performed against opposing southwesterly winds and so made more visible. In fact Canada thistle, *Cirsium arvense*, which is the preferred food plant of Painted Ladies in Alberta, was particularly abundant in central Alberta in 1983 (C.D. Bird, personal communication; see also Byers et al., in press). This accounts for the large numbers of eggs that were laid in Alberta in June and early July, and the dry summer explains the high survival rate of caterpillars and pupae that became butterflies in August 1983. In contrast, opportunities in Alberta for egg-laying by early arrivals on suitable vegetation in May and the survival rate of caterpillars from such eggs may on average be lower, so that in most years the number of butterflies remaining or produced by mid-August would be fewer. In years of early arrivals, therefore, return movements from this high latitude may be less dramatic than in years with late arrivals.

Causation

It has been suggested that outbreaks of Painted Ladies from the source areas in Mexico (and perhaps Arizona) are connected with the amount of winter rainfall in these desert areas, as in 1958 (Tilden 1962). The winter of 1982-83 was also one of unusually high precipitation (as snowfall) in the mountains of the western United States (e.g. Utah), the moisture from which would have hastened plant growth in the deserts and thus have favoured breeding there during the spring; it was presumably this that led to the arrival of a second or third generation of Painted Ladies in Alberta at the end of June. There was a particularly stong El Niño warm water intrusion in the eastern Pacific Ocean during 1982-83, and it has been suggested that this was partly or largely responsible for this precipitation, although an earlier El Niño in 1976-77 was associated with drought rather than rainfall, at least in California. Nevertheless it is remarkable that the last three major outbreaks of Painted Ladies (1958, 1973 and 1983) all closely followed warm water intrusions in 1957-58, 1972 and 1982-83 respectively. Going back further, the major Painted Lady outbreaks of 1901 and 1924 may not have been similarly associated with El Niño events, but the Painted Lady movements in 1892 (Britain), 1926 (California and Britain), 1931 (Utah and Britain), 1941 (California and Utah) and 1966 (Washington) might have been connected in some way with occurrences of El Niño that took place in 1891, 1925, 1931, 1941, and 1965 respectively. While not every El Niño event may produce precipitation in the butterfly source areas or be connected with Painted Lady outbreaks, Namias-Sumner effects (Lamb 1972) from warm water farther west and north in the Pacific (and associated blocking weather patterns and meridional patterns of wind flow) may likewise produce precipitation on the southern Pacific coast, while most of the rest of the North American continent experiences very cold winter weather. Thus, Namias-Sumner effects might explain some of those butterfly years when an El Niño was not involved and, because the meridional air flow pattern can be repeated in the eastern Atlantic, might also contribute to not infrequent synchrony in Painted Lady outbreaks between North America and Africa.

A closer examination of the relationship of weather to outbreaks is clearly required, but it seems most likely that the periodical major outbreaks of the Painted Lady have as their ultimate cause physical processes that occur well offshore in the Pacific Ocean, hundreds or thousands of miles away from the Painted Lady source areas. Whichever of several forms these physical processes take (references in Lamb 1972 and Kerr 1982), global-scale ocean-atmosphere teleconnections are probably required to explain the high frequency of near-simultaneous outbreaks of this butterfly from Mexico and North Africa into the United States and Europe respectively. Even the 21 years (28% of those from 1865-1938) when outbreaks in Europe and North America were not in the same year could be due simply to (1) the effects of El Niño not reaching Europe, (2) independent Namias-Sumner effects in the North Atlantic that might produce outbreaks from Africa but not Mexico, or (3) delay from one year to the next, in the climatic events and their effects, as between North America and Europe respectively.

Acknowledgments

I wish to acknowledge the contributions made by the individuals who told me of their observations of butterflies, and so confirmed the extent of the Painted Lady migration; they are named in Table 1 or in the text. I am grateful to Dr. C. D. Bird who commented in a helpful way on the significance of my observations at an early stage and to Dr. J. R. Byers who brought

his own study to my attention; both also provided useful historical references. A reviewer posed questions which led me to delve more deeply into several matters; this resulted in amplification of my discussion of the dynamics of Painted Lady migrations, but he is not responsible for the final product.

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Received 15 February 1984
Accepted 13 August 1984

Addenda

Some months after this paper had been proof-read in September 1984, another account of the 1983 Painted Lady migration was published by R. Wayne Nelson (Southward Migration of Painted Ladies in Alberta and British Columbia. Blue Jay 43; 7–15). Our local findings are complementary and in almost complete agreement. However, his observations extend the movement as far north as Camrose (southeast of Edmonton, Alberta) and into British Columbia, where he observed it on 30 August from between Revelstoke and the Rogers Pass south along the Rocky Mountain Trench (upper Columbia and Kootenay River valleys) into Cranbrook, Elko and Sparwood. His observations suggest that, even when the Painted Lady movement was widespread and on a broad-front on a particular day, the butterflies were not evenly distributed, e.g. although seen both north and south of Calgary on 31 August, they were not seen by either of us in that city on that day. Finally, Nelson estimated that at least 10 million butterflies were involved on 30–31 August 1983, in British Columbia and Alberta, a figure consistent with my calculations for the migration.

Received 27 March 1985

Status of Muskoxen, *Ovibos moschatus*, on Eastern Melville Island in Spring 1982

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McLaren, Margaret A., and Jeffrey E. Green. 1985. Status of Muskoxen, *Ovibos moschatus*, on eastern Melville Island in spring 1982. Canadian Field-Naturalist 99(2): 156–162.

The sex and age composition of 104 Muskoxen (*Ovibos moschatus*) in 1981 and 160 Muskoxen in 1982 were determined on the south coast of Melville Island, N.W.T. Muskoxen were in poor physical condition in spring 1982. The low fat content in longbones of six carcasses, as well as the high proportion of wood in the rumens of seven, indicated death by starvation. Few calves (6 of 474 Muskoxen classified from the air) were born in 1982 and survival of 1981 calves was poor (17.3% of 104 Muskoxen in August 1981 vs. 4.4% of 159 Muskoxen in May 1982). Despite the poor conditions in winter 1981-82, the population was generally healthy. Animals two-years old and younger comprised 23.2% of the 160 Muskoxen in our intensive study area, comparable to values found in other growing populations. A population estimate of 998 Muskoxen on eastern Melville Island in 1982 is an increase of more than 400% from 1974 after a severe winter. This is within the range observed in some natural and re-introduced populations. However, the latter occur in areas much more productive than eastern Melville Island and we believe a portion of the increase we observed is due to immigration from the historically more populous western half of the island.

Key Words: Muskoxen, *Ovibos moschatus*, Melville Island N.W.T., population status

Accounts of explorers in the Canadian Arctic indicate that Muskoxen (*Ovibos moschatus*) were abundant on Melville Island during the mid-nineteenth century (Neatby 1970). However, Muskox numbers were reduced to very low levels as a result of heavy hunting until 1917 when they were given complete protection by law. The first quantitative survey in the high Arctic was conducted in 1961 when Tener (1963) saw only 28 Muskoxen during a survey that covered 6% of the land surface of eastern Melville Island. A larger number was seen on western Melville Island. Because of the highly clumped distribution of the Muskoxen he observed, Tener (1963) made no population estimate. Miller et al. (1977), using Tener's data, suggested that over 4000 Muskoxen may have been present on the whole of Melville Island in 1961. In 1972 an estimated 3394 Muskoxen were present on Melville Island but after a severe winter in 1973-74 only 2390 remained (Miller et al. 1977). Of these only 245 were on eastern Melville Island. Miller et al. (1977) suggested that some emigration from the eastern half of the island to the historically more populous western half had occurred that winter. A subsequent survey of eastern Melville Island in 1977 indicated that the Muskox population had increased to about 400 (McLaren et al. 1977)[1]. Here we present data on the 1982 population level and the status of the population.

[1]McLaren, M. A., W. E. Renaud, R.A. Davis and J. C. Truett. 1977. Studies of terrestrial mammals on eastern Melville Island, July-August 1977. Report by LGL Ltd., Toronto, for Arctic Pilot Project, Calgary, Alberta. 110 pp.

Methods

We spent the periods 5 to 17 August 1981 and 15 April to 13 May 1982 at Bridport Inlet, southern Melville Island (Figure 1). During those periods we followed the movements of Muskox herds in an intensive study area within 25 km of the mouth of the Mecham River, and in 1982, collected rumen and longbone samples from carcasses found in that area. We also conducted an aerial survey of all of eastern Melville Island on 29 April-5 May 1982 and parts of the same area on 17 to 21 June 1982.

Muskoxen in the Bridport Inlet area were classified to sex and age from the ground using the criteria of Smith (1976) and Henrichsen and Grue (1980). In 1982, we collected two intact Muskox carcasses and, in addition, we obtained four femurs and tibias and one humerus and radius from five scavenged carcasses. Rumen samples were obtained from six scavenged carcasses as well as one intact carcass; the other intact carcass was an unweaned calf.

The two intact Muskox carcasses were necropsied by Alberta Agriculture, Animal Health Division. Longbone samples from one entire and five scavenged carcasses were analysed for marrow-fat content by Canadian Wildlife Service, Edmonton, using the dry weight method of Neiland (1970).

Rumen samples from one intact and six scavenged carcasses were kept frozen until early July 1982. All samples were then saturated with dry table salt,

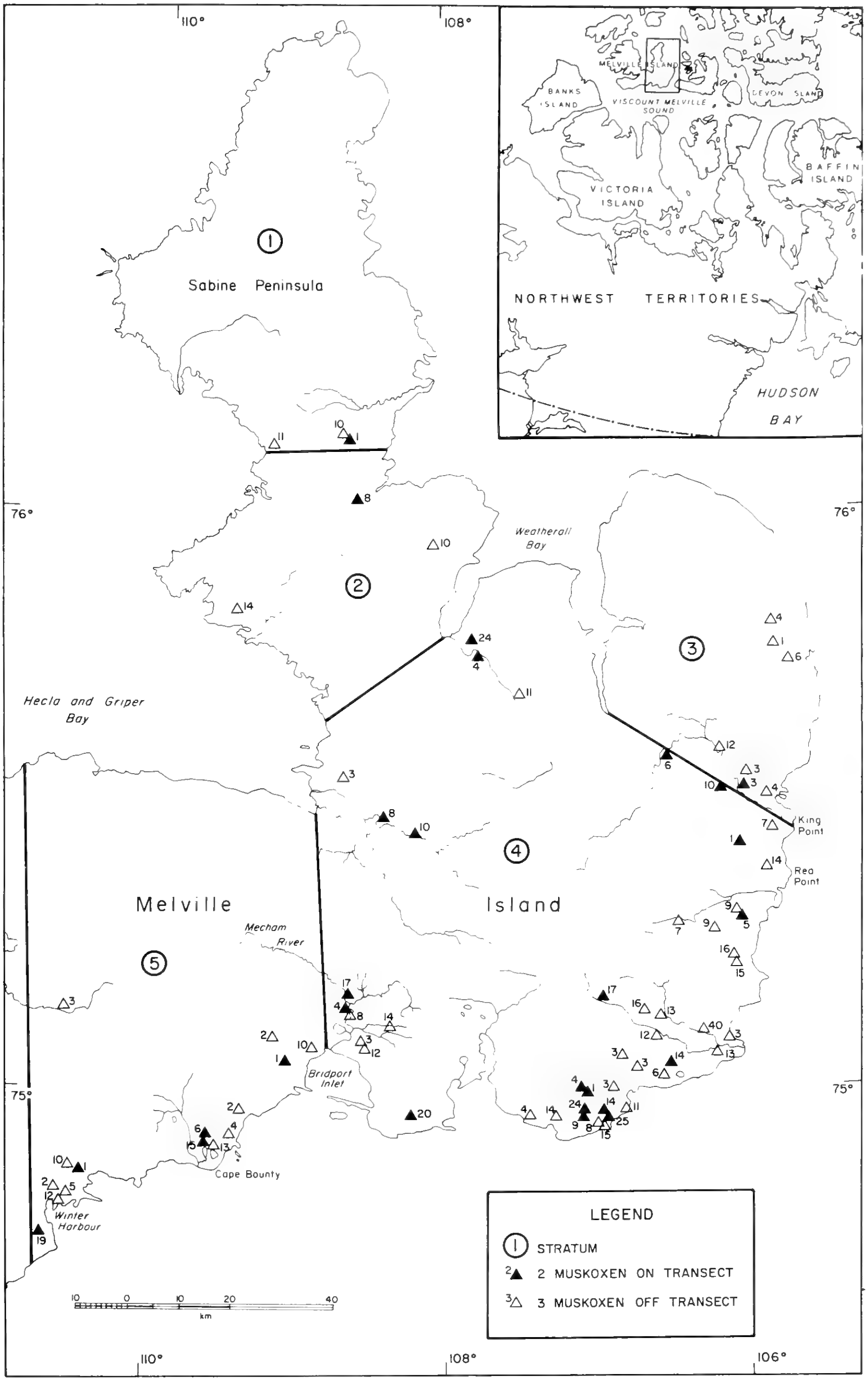

Figure 1. Muskox herds observed during an aerial survey of eastern Melville Island, 29 April–5 May 1982.

thawed, and allowed to dry thoroughly at room temperature. Microhistological analyses of rumen contents were performed by the Composition Analysis Laboratory of the Range Science Department, Colorado State University, following Sparks and Malechek (1968). The average rumen composition for each sample was based on plant fragments occurring within 100 microscopic fields (five slides of 20 fields each). Plant fragments were identified, if possible, to genus. The abundance of each genus was expressed as the mean percent relative density.

A transect survey of eastern Melville Island was conducted by 206B Jet Ranger helicopter flying at 90 m above ground level and 170 km/h. Transects were spaced 6.4 km apart and transect width was 1.6 km. Survey coverage was, thus, 25%. Three observers were present in the front left and two rear seats. Location of each sighting was plotted on a 1:250 000 topographic map. Number of individuals and, when possible, sex and age of the Muskoxen seen were recorded in a notebook. Snow cover during the survey was essentially complete resulting in high contrast and, thus, high detectability of Muskoxen. We believe that few, if any, herds on the transect strips remained undetected.

The aerial survey data were analysed on the basis of the strata defined by Miller et al. (1977). Population size was estimated based on sightings of herds by the ratio estimate of Caughley (1977) for sampling without replacement in each stratum. For an overall estimate of the number of herds on eastern Melville Island, stratum estimates and variances were pooled following Caughley and Grigg (1981). The average herd size during four intensive surveys in the Bridport Inlet area was used to provide the necessary independent estimator of herd size. This estimate was multiplied by the estimated number of herds to obtain a population estimate. The standard error of the estimate was obtained from the standard errors of herd density and herd size via Goodman's formula (Goodman 1960).

Results

We estimated a total of 998 ± SE 259.7 Muskoxen on eastern Melville Island in spring 1982, based on 27 on-transect sightings of herds and on average herd size at Bridport Inlet of 9.37 ± SD 2.3 individuals. Including observations beyond the transect strip, we actually saw 727 Muskoxen in 73 herds. Herd sizes observed during aerial surveys varied from 1 to 40 and averaged 9.7 individuals suggesting that our use of 9.37 individuals as an independent estimate of herd size may have biased the population estimate downward. The largest mean herd size observed in any stratum (10.9 individuals) occurred on stratum 4, which also supported the highest density of Muskoxen (Figure 1; Table 1). Calves and yearlings comprised 1.3% and 5.1% respectively, of 474 Muskoxen classified from the air during the first survey. During the second, partial survey in June calves comprised 3 (1.2%) of 259 Muskoxen classified.

In August 1981 calves and yearlings comprised 17.3% and 9.6%, respectively, of 104 Muskoxen classified in our intensive study area. Excluding a calf that died shortly after birth, calves comprised 1 (0.6%) of 160 Muskoxen classified from the ground in spring 1982. Muskoxen 2-4 yr old were well represented in 1982 but yearlings comprised only 4.4% of the animals classified (Table 2). In other areas yearlings comprised 16.4% to 27.9% (Table 2).

Muskox carcasses found consisted of two 2-yr old females, two 2-yr old males (one intact), two yearlings, one 1982 calf that probably died within a day of birth (collected intact) and one carcass that could not be aged.

With the exception of that of the calf, all seven of the Muskox rumens examined were moderately to fully distended and contained large amounts of woody

TABLE 1. Estimates of numbers of Muskoxen on eastern Melville Island, spring 1982.

	Stratum					
	1	2	3	4	5	Total
Area of stratum(km²)	2974	1790	1876	7040	4184	17 864
No. of transects	13	7	9	14	9	52
Area of transects (km²)	733.5	475.1	470.9	1772.5	1068.1	4520.1
No. of muskox herds seen	1	1	1	19	5	27
Density (herds/100 km²)	0.14	0.21	0.21	1.07	0.47	0.60
Estimated no. of herds	4.05	3.77	3.97	75.20	19.52	106.5
Standard error	3.59	3.23	3.71	16.49	7.06	18.9
Estimated population[1]	38	35	37	705	183	998
Standard error	33.9	30.6	34.9	228.8	78.3	248.6

[1]Based on an average of 9.37 individuals per herd. See text.

TABLE 2. Comparison of the age structure of Muskoxen in the Bridport Inlet area in spring 1982 with age structure of increasing populations in other selected areas (excluding calves of the year).

	Percent of classified animals at			
Sex-age	Bridport Inlet[1]	Sadlerochit River (1980)[2]	Nunivak Island (1968)[3]	Devon Island (1973)[4]
≥ 5-yr male	18.2	)	)	24.7
		)21.3	) 31.0	
4-yr male	6.3	)	)	4.2
3-yr male	6.9	0.0	6.5	1.6
2-yr male	10.7	9.8	9.4	(7.9)
≥ 3-yr female	45.3	31.1	30.0	36.0
2-yr female	8.1	9.8	6.7	(7.9)
Yearling	4.4	27.9	16.4	17.8
Sample Size	159	61	673	218

[1]This study.
[2]From Jingfors (1980). Four and five + year males include a group of seven bulls described as 'adult and subadult' but for which age classes of subadults were not given.
[3]From Spencer and Lensink (1970).
[4]From Hubert (1974). The sex ratio of 2–yr olds was not reported and has been assumed to be unity.

twigs and pieces as well as moss-like material. Arctic Willow (*Salix arctica*) was the most commonly consumed food and comprised 47.0-89.5% of the rumen contents (mean 67.0%, Table 3). *Saxifraga* spp. were the second most important component of the rumen samples. Other moderately abundant plant types in the rumen included mosses, club mosses, and several graminoids (*Poa* sp., *Carex* sp., and *Luzula* sp.). Forbs (with the exception of *Saxifraga* spp.) and lichens were not commonly consumed.

Fat content was estimated for the bone marrow of four 2-yr olds and two yearlings. Fat content of the proximal bones (femurs and one humerus) ranged from 0.46% to 2.54% (Table 4). Fat contents of the tibia or radius, however, were slightly higher in some animals (range of 0.83 to 15.24%). The difference in the results from proximal and distal bones probably occurred because fat reserves of proximal bones are often utilized more rapidly than fat reserves in more distal bones in some ungulates (Cheatum 1949; Brook et al. 1979; Peterson et al. 1982).

Necropsy results of the 2-yr old male and the calf showed that both were emaciated. The calf had not suckled, although our observations of it suggested that it had lived at least several hours after birth. Marrow fat content of the calf was not assessed quantitatively but visual examination showed the marrow to be red and liquid with no fat deposits apparent.

Discussion

Muskox population levels in the high Arctic and in Greenland are believed to be controlled primarily by climatic conditions (Ferns 1977; Miller et al. 1977; Thomas et al. 1981). Several instances of years with little or no calf production and occasional instances of catastrophic adult mortality related to winter conditions have been reported (Tener 1965; Vibe 1967; Gray 1973; Hussell *in* Hubert 1974; Ferns 1977; Miller et al. 1977). On the other hand, when conditions are good, Muskox populations are capable of very rapid increase (Spencer and Lensink 1970; Jingfors 1980; Vincent and Gunn 1981; Jingfors and Klein 1982).

During the decade 1972-1982, eastern Melville Island has experienced both extremes. The population declined by 59% between the summers of 1973 and 1974 as a result of high mortality and, probably, some emigration (Miller et al. 1977). Subsequently, numbers of Muskoxen increased to about 400 in 1977 (McLaren et al. 1977) and 998 in spring 1982. The very high proportion of 2-, 3- and 4-yr olds in our intensive study area suggests extremely high calving rates and excellent overwinter survival for several years prior to 1982. This is especially true since winter mortality in 1981-82 apparently affected animals 2 yr and younger more than other age classes. Comparisons with other increasing populations (Table 2) demonstrate the very young age structure of Muskoxen on eastern Melville Island.

The winter of 1981-82 was moderately hard for Muskoxen on eastern Melville Island. Overwinter survival of 1981 calves was poor (17.3% of categorized Muskoxen in August 1981 vs. 4.4% in May 1982). Very few calves were produced in 1982 and both the bone marrow and rumen analyses suggested starvation as either the proximate or ultimate cause of death in the carcasses found. Only two calves were seen in 1982 among 161 Muskoxen classified during intensive ground studies and one of these died, probably less

TABLE 3. Relative composition of seven rumen samples from Muskox carcasses found near Bridport Inlet, April-May 1982.

Plant Genera	% occurrence	% Relative density	
		Mean	S.D.
Lichens			
Peltigera	14.3	0.07	0.45
Mosses			
Moss (genera unknown)	85.7	2.55	2.34
Club mosses			
Lycopodium	100.0	4.00	2.83
Graminoids			
Agropyron	14.3	0.09	0.59
Carex	57.1	4.16	6.75
Eriophorum	14.3	0.06	0.36
Festuca	28.6	0.30	1.08
Juncus	14.3	0.07	0.45
Luzula	71.4	3.34	5.95
Poa	100.0	2.82	3.42
Forbs			
Astragalus-Oxytropis	14.3	0.11	0.71
Cassiope	14.3	0.06	0.41
Cerastium	42.9	0.26	0.96
Dryas	42.9	0.34	0.95
Potentilla-Geum	28.6	0.16	0.70
Saxifraga	100.0	14.49	13.85
Salix arctica	100.0	67.00	17.40

than a day after birth. During the aerial survey only six (1.3%) of 474 classified Muskoxen were calves. In contrast, on Devon Island, calves comprised 16.8% to 19.1% of Muskoxen classified in mid to late May in 1971-73 (Hubert 1974). Based on these percentages, we would have expected 25 to 30 calves in our intensive study area by the end of our study even though the calving season would not have been complete. A subsequent aerial survey in June 1982 confirmed poor calving success. Only 3 (1.2%) of 259 Muskoxen classified in June were calves.

Percent fat in the bone marrow of the six specimens examined was extremely low and the seven rumens examined contained large amounts of wood and other willow fragments. Low percentages of marrow fat have been found to be associated with poor body condition in a number of ungulate species (Harris 1945; Cheatum 1949; Neiland 1970; Coady 1973; Franzmann and Arneson 1976; Hunt 1978; Kie 1978; Parker et al. 1975; Thomas et al. 1977; Ratcliffe 1980; Peterson et al. 1982; Thomas 1982). Similarly, a large amount of willow compared to grasses or sedges in winter rumens is considered evidence of malnutrition (Parker 1978). Thus, these animals either starved or, if killed by predators, their poor condition probably increased their susceptibility to predation.

TABLE 4. Percent fat content of bone marrow from Muskox bones collected near Bridport Inlet, Melville Island, April-May 1982. Values given are the mean percent fat content for the upper and lower portions of each bone, corrected for non-fat residues according to Neiland (1970).

Animal #	% Fat	
	Proximal bones[1]	Medial bones[1]
(1) 2-y Female	2.36	3.46
(2) 2-y Female	0.76	0.83
(3) Yearling (Sex unknown)	2.21	2.04
(4) 2-y Male	1.74	10.28
(5) Yearling (Sex unknown)	2.54	15.24
(6) 2-y Male	0.46[2]	—

[1]In all samples except (2), proximal and medial bones are the femur and tibia, respectively. In sample (2) proximal and medial bones are the humerus and radius, respectively.
[2]Only one sample of bone marrow from the central portion of the femur was obtained during the necropsy.

The relatively small herd sizes observed in 1982 also indicate severe winter conditions. Muskox herds on Melville Island in winter typically contain an average of 12 to 24 individuals (Miller et al. 1977; Thomas et al. 1981). Herds seen during the aerial survey in 1982 averaged only 9.7 individuals, a size more typical of summer herds. Miller et al. (1977) observed small herd sizes on Bathurst Island during the catastrophic winter of 1973-74 and postulated that heavy snow cover on the preferred meadows forced the animals to feed in sparsely vegetated uplands where only small groups could be supported. In spring 1982, deep, hard snow did cover portions of the most productive habitats near Bridport Inlet but other portions with shallower and soft snow were available and used by Muskoxen. Muskoxen in 1982 may have been restricted to smaller areas than usual but we have no comparative data from other years. One factor that may have affected the ability of Muskoxen to feed during 1981-82 was wind. Lengthy periods of high winds and blowing snow may have prevented feeding and resulted in an accumulated energy deficit. Winds greater than 30 km/h occurred 29.4% of the time in winter 1981-82 compared to only 16.5% in winter 1980-81 (Table 5).

The rapid increase in numbers of Muskoxen on eastern Melville Island from 1974 to 1982 suggests immigration as well as reproductive recruitment. Miller et al. (1977) estimated that only 169 Muskoxen were in strata 4 and 5 (see Figure 1) after the catastrophic 1973-74 winter. In 1977, 416 Muskoxen were

Table 5. Percentage distribution of wind speed records for Rea Point, Melville Island, N.W.T., October through April 1980-81 and 1981-82[1].

	Wind Speed (km/h)		
Year	0–30	31–50	> 50
1980–81	83.5	12.7	3.8
1981–82	70.6	22.7	6.7

[1]Based on eight records per day.

estimated to be in these two strata (McLaren et al. 1977). By 1982, an estimated 888 Muskoxen were in strata 4 and 5.

Rates of increase for natural Muskox populations have been estimated at 1% to 24% per year for introduced populations in Alaska (Spencer and Lensink 1970; Jingfors and Klein 1982) and 13% to 25% for Muskoxen on Banks Island, N.W.T., from 1972 to 1979 (Vincent and Gunn 1981). Increases observed on eastern Melville Island would represent an average annual recruitment of 35% from 1974 to 1977 and 16% from 1977 to 1982 if they had resulted entirely from reproduction. However, very few calves were produced in 1982 and thus the effective rate of population increase was about 20% from 1977 to 1981 but close to zero from 1981 to 1982. A sustained increase of 20% or better per year appears to be within the capabilities of Muskoxen but the low productivity and harsh climatic conditions of the high Arctic (north of 70°), in comparison with areas where such rates have been recorded, suggests that such a rate is unlikely.

The major route of immigration to eastern Melville Island has probably followed the south coast. Western Melville Island, especially the Bailey Pt. area, has been postulated to be a refugium to which some Muskoxen retreat in especially bad winters and from which they subsequently reinvade other parts of the island (Miller et al. 1977; Thomas et al. 1981). Similar refugia are believed to occur in Greenland (Henrichsen 1982). On eastern Melville Island, the south and east coastal plain, and adjacent river valleys have consistently supported the largest numbers of Muskoxen. Miller et al. (1977) reported no Muskox herds along the south coast of Hecla and Griper Bay and we saw none in this area in either 1977 (McLaren et al. 1977) or 1982. Relatively few Muskoxen occur on the Sabine Peninsula despite abundant apparently suitable habitat (Miller et al. 1977; McLaren et al. 1977; this study), If Muskoxen immigrating from western Melville Island have reached the Sabine Peninsula, it seems most likely that they arrived from the south or possibly the east coast after crossing the divide between major rivers draining the central plateau.

Muskox numbers on eastern Melville Island have increased at an average annual rate of 20–35% since the major population crash in 1973–74. It is unlikely that this rate of increase resulted from reproduction alone. Rather, immigration from western Melville Island has probably contributed to the increase. Nevertheless, the young age structure of animals on eastern Melville Island suggests that survival of calves from at least 1978 to 1981 was excellent.

The winter of 1981–82 was moderately severe. Some mortality, mainly among animals 2-yr and younger, was observed; survival of 1981 calves over the winter was poor; and very few calves were born in spring 1982. As a result, two year classes will be absent or nearly so in the future breeding population. However, Muskoxen are long-lived animals (Tener 1965), and the absence of two cohorts will have little effect on the potential rate of increase of the population.

Acknowledgments

This study was funded by Arctic Pilot Project, Calgary, Alberta. Michael Robertson and Ted Spearing of Arctic Pilot Project gave assistance. Ted Spearing also served as third observer during most aerial surveys. W. J. Richardson provided statistical advice. M. P. Van Ieperen of Panarctic Oils Ltd. provided wind data for Rea Pt. The following people and organizations also assisted in various aspects of the study: E. Allakariallak, D.C. Thomas, D. K. Onderka, G. Dionne, Narwhal Arctic Services, and Panarctic Oils Ltd.

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Received 18 November 1983
Accepted 29 July 1984

Demographic and Dietary Comparisons of Forest and Farmland Coyote, *Canis latrans*, Populations in Alberta

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Todd, Arlen W. 1985. Demographic and dietary comparisons of forest and farmland Coyote, *Canis latrans*, populations in Alberta. Canadian Field-Naturalist 99(2): 163–171.

Demographic and dietary comparisons of Coyotes, *Canis latrans*, in forest (> 50% forest cover) and adjoining agricultural (> 50% cleared) habitats of Alberta were made during 1972-75 by examining 1038 carcasses obtained from trappers, hunters, and other sources. During this period, Coyote populations in the forest declined about 2-4 fold in response to a continuing cyclic decline of Snowshoe Hares, *Lepus americanus* (from intermediate to scarce levels of abundance), whereas farmland Coyote populations evidently did not. Farm carrion was the single most important winter food of Coyotes in both forest and farmlands (33 and 61% volume in stomachs, respectively), although its availability was evidently limited in the forest. Use of Snowshoe Hares declined with hare abundance in both habitats; alternate foods were apparently not adequate during hare scarcity in the forest as rates of total food consumption by forest coyotes appeared to decline. Body-fat indices were generally lower, and overwinter fat losses generally greater, for forest coyotes. Pregnancy rates varied more between years in forest habitats and were lower ($P = 0.06$) among adults than in agricultural habitats (63% vs. 86%). The proportion of juvenile Coyotes declined in the forest ($P < 0.001$) after 1972-73, once hares became scarce, but not in agricultural habitat. Sex ratios of Coyotes favored males in the forest when hares were at intermediate levels ($P < 0.05$), but were balanced otherwise. Relative stability in numbers, physical condition, breeding rates and age and sex structure in agricultural compared to forest habitats is attributed to more favorable environmental conditions for Coyotes in the former.

Key Words: Coyote, *Canis latrans*, demography, diet, Alberta, forest, farmland.

Although several extensive studies have shown that food habits of Coyotes, *Canis latrans*, may vary markedly within and between habitats (Sperry 1941; Ferrel et al. 1953; Fitcher et al. 1955; Gier 1975), there are no detailed comparisons of Coyote demography. Coyote populations in central Alberta have been studied for over a decade (Wetmore et al. 1970; Nellis and Keith 1976; Todd and Keith 1976; Todd, Keith and Fischer 1981); their population dynamics appear to differ markedly between boreal forest and adjoining agricultural habitats. The cyclic Snowshoe Hare, *Lepus americanus*, is an important prey species in the forest, and Coyotes there fluctuate with the hare (Todd, Keith and Fischer 1981; Todd and Keith 1983). In contrast, farm carrion is the staple winter diet of farmland Coyotes (Todd and Keith 1976; Wetmore et al. 1970), whose numbers appear far more stable, with no clear evidence of a 10-year cycle. Cleared agricultural areas, of course, are non-habitat for Snowshoe Hares.

Field studies of Coyote populations in the intensively cultivated Westlock area (Todd and Keith 1976) and the largely forested Rochester area (Todd, Keith and Fischer 1981) during 1972–75 were augmented by laboratory examinations of Coyote carcasses from hunters, trappers, and other sources. Carcasses were also obtained from trappers throughout most forested regions of Alberta during the winters of 1972–73 through 1974–75 (Todd and Keith 1983). The objective was to document the demographic basis of Coyote population change as Snowshoe Hares declined from high to low levels.

This paper compares diet, physical condition, reproductive performance, and age and sex structure of Coyote populations in contiguous forested vs. agricultural habitats of east-central and southern Alberta. This study is the first to explore demography of Coyote populations in different habitats in relation to Coyote food habits, winter conditions, and other environmental factors. An understanding of Coyote population processes is essential for improved management in northern regions, where relatively high fur prices have resulted in intense human exploitation of Coyotes in recent years (Todd and Giesbrecht 1979).

Study Area and Methods

Carcass Collection

During winters 1972-73 through 1974-75, 542 Coyote carcasses from forested (< 50% cleared) habitats and 496 from agricultural habitats were obtained in east-central and southern Alberta (south of 56°N latitude and east of 115° longitude).

Forest habitats sampled in the present study were predominantly Aspen (*Populus tremuloides*) — dominated boreal forest, although subalpine and montane forest types (Rowe 1972) in the Rocky Mountains of southwestern Alberta were included. Agriculturally cleared habitats sampled included aspen parkland

(Bird 1961) and adjoining areas along the forest fringe. Coyotes were not obtained from grassland habitats in southeastern Alberta.

Laboratory Techniques

Laboratory methods have been described elsewhere (Todd, Keith and Fischer 1981; Todd and Keith 1983) and are summarized here only briefly. Gastrointestinal contents were weighed, and measured volumetrically; food items were sorted, identified and percent volumes were visually estimated. Female reproductive tracts were examined for evidence of estrus, fetuses and placental scars; then fixed in 10% formalin, cleared, and re-examined. Fixed ovaries were sectioned and examined microscopically for corpora. Initial age classification of specimens into juvenile (< 1 year) and older age classes was made from composite criteria including tooth eruption, closure of the humeral epiphysis, and closure of the root of the lower canine. Estimated age in years of individuals > 1 year old was based on cementum layers in a lower canine. Three indices of body fat were measured and equated directly with nutritional status. Renal fat and total subcutaneous fat were appraised visually on a scale of 1 (none) to 4 (abundant), and xiphoid-process fat globules (XPFG) were excised and weighed.

Weather Conditions

Winter weather conditions were indexed from records at the Meanook Meteorological Observatory located in central Alberta 26 km north of Rochester; more than half the Coyotes were collected within an 80-km radius of Rochester. Resultant trends in winter severity were representative for the entire study region (Gunson 1979).

Results

Weather Conditions

The three winters of carcass collections showed extreme differences in snowfall, snowdepth, duration of snow cover, and mildness of temperatures (Table 1). 1972–73 and 1974–75 were characterized by light snowfalls both early and late and below normal snowfalls and snow depths throughout the winter. In addition, 1972–73 was unusually mild during 1 December-31 March, although 1974–75 was normal in that respect. In contrast, 1973–74 had unusually heavy snowfalls both early and late, winter-long snowfalls and snowdepths nearly double the norms, and infrequent respites from low temperatures. The winter of 1973–74 was unusually severe across the entire prairie region of Canada (Gunson 1979).

Diet

Snowshoe Hares, mice, voles, and farm carrion commonly occurred in gastrointestinal contents of Coyotes killed in both forest and agricultural habitats (Table 2). Farm carrion was the single most important food, but its use in forest was half that in farmlands (Table 3). There is a bias of unknown magnitude in the food habits data from trapped Coyotes because I was unable to separate remains of baits used by trappers from prey and carrion ingested naturally (Todd and Keith 1983). That bias may be greatest in food habits data from forest Coyotes, as a higher proportion were trapped in forests.

Hare occurrence in the diet of forest Coyotes was twice that of farmland Coyotes, whereas mice and voles (chiefly *Microtus pennsylvanicus*) occurred more frequently in the diet in agricultural areas (Table 2). Dietary use of ungulates by farmland Coyotes was low (Tables 2, 3). The Coyote diet thus seemed to reflect important differences in food availability between habitats.

Consumption of Snowshoe Hares by Coyotes declined with hare populations during 1972–75. Occurrence among forest-dwelling Coyotes declined from 46–55% during 1972–73, when hare abundance was intermediate, to 0% by 1974–75 (Table 2), when

TABLE 1. Weather conditions during winters 1972–73, 1973–74 and 1974–75 as recorded at the Meanook Meteorological Observatory.

Winter	Snowfall, cm Oct.-Nov.	Snowfall, cm Mar.-May	Snowfall, cm All Winter[a]	Mean winter-long snow depth, cm	*N* days with maximum temperature > 0°C, 1 Dec.-31 Mar.
1972–73	26.9	18.5	94.7	16.5	45
1973–74	64.5	59.4	289.6	37.6	18
1974–75	15.2	33.5	102.4	13.7	30
Normal[b]	[c]	[c]	156.7	20.1	31

[a]1 October–31 May
[b]Based on average of 11 years during 1965–66 and 1974–75.
[c]Data not available

TABLE 2. Percent occurrence[a] of food items in 728 stomachs and 513 intestines of Coyotes obtained in agricultural and forested habitats in southeastern Alberta during 1972–73 to 1974–75.[b]

	Forest				Agricultural			
Food item	1972–73	1973–74	1974–75	Total	1972–73	1973–74	1974–75	Total
Snowshoe hare	46(55)	10 (6)	0 (0)	26(30)	23(30)	8 (4)	0 (0)	15(17)
Mice and voles	32(17)	19 (8)	46(27)	28(14)	43(34)	24(20)	37(55)	33(29)
Coyote	5(14)	15(10)	11(12)	10(12)	9(10)	6 (4)	11 (0)	8 (7)
Ungulates	7 (3)	7 (9)	24 (3)	8 (6)	5 (2)	1 (0)	5 (0)	3 (1)
Other native prey	19 (5)	16(10)	14(12)	17 (7)	14 (7)	8 (5)	26(18)	12 (7)
Farm carrion	21(10)	39(30)	46(27)	31(20)	41(21)	62(43)	68(73)	55(33)

[a]Number of occurrences of an item divided by total number containing food. Percent occurrences in intestines are parenthesized.
[b]Numbers of stomachs with contents from the forest was 193, 175, and 37 compared to 145, 159, and 19 from agricultural areas during 1972–73, 1973–74, and 1974–75, respectively. Number of intestines with contents from the forest was 144, 113, and 26 compared to 122, 97, and 11 from agricultural habitats during 1972–73, 1973–74, and 1974–75, respectively.

TABLE 3. Percent volume of food items in 728 stomachs of Coyotes taken in agricultural and forested regions during 1972–73 to 1974–75.

	Forest				Agricultural			
Food item	1972–73	1973–74	1974–75	Total	1972–73	1973–74	1974–75	Total
Snowshoe Hare	31	7	0	18	20	4	0	11
Mice and voles	11	3	18	9	18	9	11	13
Coyote	3	18	tr	8	2	3	1	2
Ungulates	6	11	33	11	3	*tr*	2	2
Other native prey	7	7	6	7	5	3	6	4
Farm carrion	29	39	31	33	47	74	50	61
Other	12	16	12	13	6	7	30	8

hares were at their cyclic low. Percent volume declined from 31 to 0% (Table 3). Food habits of agricultural Coyotes responded similarly to the hare decline, but the magnitude of change was less (Tables 2, 3). As consumption of hares decreased, use of farm carrion and alternative native prey generally increased in both habitats, as did use of such "other" food items as cereal grains, vegetation, and garbage in agricultural habitats (Table 3).

Use of ungulates by forest coyotes increased markedly over the 3-year period (Tables 2, 3). The increase from 1972–73 to 1973–74 (Table 3) doubtlessly reflects increased scavenging on winter-killed deer during the latter severe winter, but may reflect increased Coyote predation as well. White-tailed Deer (*Odocoileus virginianus*) in the Rochester district of central Alberta were reported unusually vulnerable to Coyotes in March 1974 when snows were very deep and thickly crusted (B. F. Young, personal communication).

Age-Sex Differences in Diet

Occurrences of selected food items in stomach contents were tested (Chi-Square) for within-habitat differences in the diet between age-sex classes. Sample sizes (number of stomachs with contents) ranged from 159–169 in forest, and from 120–179 in agricultural habitats. Mice and voles occurred in higher proportions ($P < 0.05$) of stomach contents of juveniles in both forest (34 vs. 23%) and agricultural (36 vs. 25%) habitats, whereas ugulates occurred in a higher proportion ($P < 0.01$) of adult Coyotes in forest (12 vs. 4%). Mice and voles occurred in a higher proportion ($P < 0.005$) of stomachs of females in agricultural habitats (43 vs. 22%), whereas farm carrion tended ($P = 0.14$) to occur more frequently in males (58 vs. 49%). Likewise, in forest habitats, mice and voles tended to occur more often ($P = 0.13$) in females (32 vs. 24%), while ungulates tended ($P = 0.18$) to occur more often in stomach contents of males (11 vs. 6%). Observed differences in food habits seem to reflect differences in Coyote body size related to sex and age, possibly dominance hierarchies in feeding on carcasses of large mammals (Camenzind 1978; Bowen 1981), and possibly age-related differences in hunting skill.

Indices to Rates of Food Consumption

Of four indices to rates of food consumption by forest Coyotes, two indicated reduced consumption as

TABLE 4. Indices to rates of food consumption by Coyotes in forested and agricultural habitats in Alberta during 1972–73 to 1974–75. Sample sizes in parentheses.

	Forest				Agricultural			
Index	1972–73	1973–74	1974–75	*P*-level	1972–73	1973–74	1974–75	*P*-level
Mean weight of stomach contents(g)	244(188)	193(173)	218(37)	>0.20[a]	273(143)	281(159)	172(19)	<0.005[a]
Mean volume of intestinal contents (ml)	59(158)	42(116)	46(26)	<0.005[a]	55(118)	46(97)	59(11)	>0.20[a]
Percent stomachs containing food	81	76*	82	>0.20[b]	80	85*	83	>0.20[b]
Percent intestines containing food	70	52	59	<0.005[b]	67	56	50	$= 0.06$

[a]*P* determined by analysis of variance.
[b]*P* determined by chi-square test.
*denotes a significant ($P = 0.05$) difference between habitats; as determined by chi-square test.

hares declined to scarcity (Table 4): (1) Mean volume of intestinal contents declined ($P < 0.005$) from 1972–73 to 1973–74 and 1974–75; and (2) the proportion of intestinal tracts containing food declined ($P < 0.005$) between 1972–73 and the two following years. Two indices to food consumption for agricultural Coyotes also tended to indicate a reduction during the 3-year period, however (Table 4): (1) the proportion of intestinal tracts containing food declined ($P = 0.06$) progressively from 1972–73 to 1974–75; and (2) weight of stomach contents differed ($P < 0.005$), being highest in 1973–74 and lowest in 1974–75. Todd and Keith (1983) suggested indices based on intestinal contents were less biased by baits than those based on stomach contents. Therefore, observed trends among forest Coyotes may be more meaningful.

I compared proportions of stomachs and intestines containing food between habitats. The only difference ($P = 0.05$) was in 1973–74, when 85% of Coyote stomachs in agricultural areas contained food vs. 76% in forested areas (Table 4). Due to potential biases stemming from differences in collection methods, I did not compare stomach weights and intestinal volumes between forest and agricultural Coyotes. To illustrate, rifle hunters in agricultural habitats sometimes shot Coyotes as they were feeding at carrion sources, whereas Coyotes trapped in forested areas may have been held in traps for some time before death without feeding.

In summary, rates of food consumption by forest Coyotes appeared to decline after hares declined below intermediate levels, whereas rates of food consumption by Coyotes in agricultural habitats showed no consistent trend during 1972–75. Carrion was presumably more plentiful in farming areas, and provided a continuing accessible supply of food (Todd and Keith 1976).

Fat Reserves

Todd and Keith (1983) showed that renal, subcutaneous, and XPFG deposits of forest Coyotes differed between age and sex classes, between levels of hare abundance, and between early and late winter. I therefore compared these in examining the fat indices of forest and agricultural Coyotes.

XPFG weights of forest Coyotes declined from early to late winter in 10 out of 12 possible cases (Table 5); significant ($P < 0.05$) overwinter declines were shown by adult females in two of three years. Overwinter declines in XPFG weights were less consistent (7 out of 10 cases) and generally smaller among agricultural Coyotes (Table 5); in five out of seven cases where XPFG weights declined in both forest and agricultural Coyotes, overwinter declines were smaller for agricultural Coyotes. Fat indices of agricultural Coyotes were greater than those of forest Coyotes in 17 out of 22 comparisons (Table 5); 2 of 3 significant ($P < 0.05$) differences were shown by adult females.

It is unlikely that collection methods account for observed differences in fat indices. Cooperating trappers often used neck snares in trail sets; such snares, when properly equipped and set, likely result in quick death as a rule. Leghold traps were commonly used as well, but were likely checked once every 2–3 days, for the most part (Meredith and Todd 1979:56). The average coyote would therefore be held less than 1–1½ days prior to death, likely too short a time to significantly mobilize fat reserves. Moreover, the fact that gastrointestinal systems of most coyotes contained food (Table 4) itself argues against prolonged inanition and concomitant mobilization of fat reserves. In any event, bias in collection methods cannot account for observed differences in overwinter fat declines.

TABLE 5. Mean indices to xiphoid-process fat deposits for Coyotes collected during early and late (before vs. after 1 January) winter during 1972–73 to 1974–75. Sample sizes in parentheses.

Age and sex	Habitat	1972–73		1973–74		1974–75		Combined	
		Early	Late	Early	Late	Early	Late	Early	Late
Juv M	Forest	* 29(33)	18(21)	38(24)	36(21)	14(2)	40 (8)	32(59)	29(50)
	Agricultural	44(28)	23(18)[a]	32(32)	26(16)		42(24)	38(60)	32(58)
Juv F	Forest	24(18)	16(17)	23(24)	19(16)	48(4)	18 (6)	26(46)	18(39)
	Agricultural	30(26)	23(17)	24(20)	25(20)	19(2)	26(21)	27(48)	25(58)
Ad M	Forest	32(20)	38(27)	60(17)	40(52)	56(3)	54 (9)	46(40)	41(88)
	Agricultural	48 (8)	49(14)	63(15)	45(17)		48(17)	58(23)	47(48)
Ad F	Forest	36(14)	* 21(24)[a]	41(23)	26(43)[a]	82(3)	* 20 (6)	42(40)	24(73)
	Agricultural	47 (9)	36(12)	53 (9)	39(20)	41(2)	40(15)	49(20)	39(47)

[a]Denotes significant ($P < 0.05$) decline from early winter; as determined by t-test.
*Denotes difference ($P < 0.05$) between habitats; as determined by t-test.

TABLE 6. Age-specific reproductive statistics for female Coyotes obtained from forested and agricultural habitats in Alberta during 1972-74. Sample sizes in parentheses.

Reproductive parameter	1972		1973		1974		Combined	
	Year and habitat type							
	Forest	Agri-cultural	Forest	Agri-cultural	Forest	Agri-cultural	Forest	Agri-cultural
% ovulating								
Yearling	52(29)	53(15)	63(30)	27(26)	25(4)	43(7)	* 56(63)	* 38(48)
Adult	92(13)	100 (5)	94(34)	100(10)	100(7)	100(6)	94(54)	100(21)
Mean number of corpora lutea								
Yearling	5.9(11)	4.9 (5)	4.8(16)	5.2 (6)	—(0)	4.3(3)	** 5.3(27)	** 4.9(14)
Adult	7.9(11)	7.3 (3)	6.6(27)	8.6 (8)	6.0(8)	5.5(6)	6.8(46)	7.3(17)
% pregnant								
Yearling	24(29)	20(15)	30(30)	23(26)	0(4)	29(7)	* 25(63)	* 23(48)
Adult	69(13)	100 (5)	56(34)	80(10)	86(7)	83(6)	63(54)	86(21)
							***	
Mean in utero litter size								
Yearling	4.4 (7)	4.3 (3)	3.8 (9)	3.4 (5)	—(0)	2.0(2)	4.1(16)	** 3.4(10)
Adult	5.3 (9)	6.0 (5)	4.5(19)	4.3 (8)	4.5(6)	4.4(5)	4.7(34)	4.8(18)

*Denotes difference ($P < 0.005$); as determined by chi-square.
**Denotes difference ($P < 0.05$); as determined by t-test.
***Denotes nearly significant difference ($P = 0.06$); as determined by chi-square.

Results shown by renal and subcutaneous fat indices were similar to XPFG weights. Renal and subcutaneous indices may be obtained for a nominal fee from the Depository of Unpublished Data, CISTI, National Research Council of Canada, Ottawa, Canada K1A 0S2. Overall, fat indices suggested less nutritional stress in the farmlands.

Reproduction

The ovulation rate of adult females in agricultural and forest habitats equalled or approached 100% each year (Table 6). Ovulation rates of yearlings averaged 56 and 38% ($P = 0.06$) in forest and agricultural habitats. The proportion of yearlings ovulating in forest habitats was highest in 1973 (63%), following a short, mild, low snowfall winter when hares were intermediate, and lowest in 1974 (25%) following a severe winter when hares were scarce ($P > 0.25$). Ovulation rates of agricultural yearlings ranged from 53–27%.

The mean number of corpora lutea per ovulating female did not differ ($P > 0.05$) between habitats or between years within habitats, for either yearlings or adults, although mean corpora lutea counts among

forest adults progressively declined from 7.9 to 6.0 as hares declined from 1972–74 (Table 6). The mean number of corpora lutea per ovulating adult was also lowest (5.5) in agricultural habitats in 1974, following the severe winter. Numbers of corpora lutea differed between yearlings and adults in forest (5.3 vs. 6.8, $P < 0.05$) and in agricultural habitats (4.9 vs. 7.3, $P < 0.025$).

Overall pregnancy rates for yearlings were very similar (23–25%) in forest and agricultural habitats (Table 6). The pregnancy rate among yearlings differed ($P < 0.005$) from adults in both habitats. For adults, the overall pregnancy rate was appreciably higher ($P = 0.06$) in agricultural habitats (86 vs. 63%). Pregnancy rates varied little in the farmlands, ranging from 20–29% for yearlings and from 80–100% for adults ($P > 0.250$). Pregnancy rates varied more greatly between years in the forest, ranging for yearlings from 30% in 1973 to 0% in 1974, and for adults from 56% in 1973 to 86% in 1974 ($P > 0.250$).

In utero litter sizes in forest of 4.1 for yearlings and 4.7 for adults compared to 3.4 and 4.8 in agricultural habitats (Table 6). In utero litter sizes of yearlings differed ($P < 0.05$) from adults only for agricultural habitats. Litter sizes of both yearlings and adults declined after 1972 in both habitat types.

In summary, pregnancy rates for adult and yearling Coyotes tended to be lower and vary more between years in forest habitats. Changes among yearlings in the forest were related to hare abundance and winter length and/or severity. However, rates for yearlings in forest were higher overall than in the farmlands, largely due to the relatively high reproductive rate following the short mild winter of 1972–73. The mean number of corpora lutea per ovulating female declined for both age classes in the forest after 1972 (paralleling hare abundance), whereas mean corpora lutea counts in agricultural habitats (both age classes) were highest in 1973, following the short mild winter, and lowest in 1974, following the long severe winter. Estimated litter sizes of both age classes declined after 1972 in both habitats, but were based on small samples. Overall, available data indicate that both breeding rates and litter sizes were related to hare abundance and winter severity in the forest; likewise, litter sizes in agricultural habitats appeared to vary with winter severity, while breeding rates tended to remain constant.

Age and Sex Structure

I restricted comparisons of age and sex structure to between years within habitats, as between-habitat comparisons were potentially biased by differences in collection methods (see review by Todd and Keith 1983). For example, Coyotes were predominantly trapped or snared in forest habitats, whereas in agricultural habitats, numbers were taken by sport hunting with rifles, as well as with dogs (coursing and/or trailing hounds), and poison baits. The proportion of juveniles was higher among samples taken by sport-hunting with rifles and dogs (Table 7), and road-kills (64–75%) than other samples (52–55%). Sex ratios did not differ ($P > 0.05$) from 50:50 however, except for the 1972-73 trapped/snared sample (Table 7), which favored males ($P < 0.01$).

TABLE 7. Age and sex composition of Coyote samples in Alberta in relation to cause of death.

Method	N	Sex ratio (M : F)	% juveniles[a]
Trapped/snared[b]			
1972-73	254	*59:41	52
1973-74	90	48:52	55
Rifle	79	51:49	64
Hunting dogs	56	55:45	75
Poison	71	48:52	54
Vehicle	25	56:44	65

[a]The proportion of juveniles differed ($P < 0.05$) between samples (Chi-Square in 6×2 contingency table).
[b]Sex ratios differed between 1972-73 and 1973-74 (Chi-square, $P < 0.05$) and are therefore presented separately.
*Denotes difference ($P < 0.01$) from 50:50 sex ratio; as determined by Chi-square.

The proportion of juveniles in forested habitats declined ($P < 0.01$) after 1972–73 (Table 8) as hares became scarce, being lowest (39%) in 1973–74, following reduced litter sizes and lowered pregnancy rate of adults in spring 1973 (Table 6). The proportion of juveniles in agricultural habitats also decreased from 1972–73 to 1973-74 ($P = 0.14$), but to a lesser extent (Table 8). The mean age of coyotes increased (50–58%) in both habitats after 1972–73 (Table 8), although appreciable change did not occur in agricultural habitats until 1974–75, following 2 years of somewhat lowered reproduction (Table 6).

Sex ratios overall (all age classes combined) did not differ ($P > 0.05$) from 50:50 except in forested habitats during 1972–73, when males were favoured (58% males (Table 8)). Sex ratios within juvenile, yearling, and adult age classes were unbalanced ($P < 0.05$) only among juveniles in the forest, and then only during 1972–73 (60% of 100 juveniles were males). These results parallel Todd and Keith's (1983) finding that sex ratios of Coyotes trapped throughout forested Alberta favoured males as hares declined, but were balanced during hare scarcity (note also unbalance favouring males in trapped/snared sample in 1972–73 but not in 1973–74 (Table 7)). This provides further evidence for changes in tertiary sex ratios in canid populations in relation to density and/or food supply (Mech 1975; Kleiman and Brady 1978).

TABLE 8. Age and sex composition of Coyotes collected from forested and agricultural habitats in Alberta during 1972-73 to 1974-75.

Habitat	Winter	N	Sex ratio (M : F)	Age composition (%)				
				< 1 yr	1-2 yr	2-3 yr	> 3 yr	$\overline{X}$
Forest	1972-73	199	*58:42	54	33	6	7	1.2
	1973-74	226	51:49	39	30	12	19	1.8
	1974-75	47	53:47	49	23	9	19	1.9
Agricultural	1972-73	132	50:50	68	24	5	3	1.0
	1973-74	217	55:45	58	28	8	6	1.2
	1974-75	83	51:49	59	20	6	15	1.5

*Denotes difference ($P < 0.05$) from 50:50 sex ratio; as determined by chi-square.

Discussion

Foods and Fat Reserves

Food habits results in this study augment earlier ones which have shown that the diet of Coyotes varies markedly and is determined largely by food availability (see review by Todd, Keith and Fischer 1981). Use of Snowshoe Hares and ungulates was greater in forested habitats, while use of farm carrion was less (Table 3). Although the biomass of available farm carrion was likely much greater in the more intensively farmed areas, farm carrion was, nevertheless, the single overall most important winter food in forested areas. This reflects the winter reliance of Coyotes on carrion, except during years of hare abundance (Todd, Keith and Fischer 1981). Other notable foods in the forest in some years were mice and voles and ungulates (both in 1974–75), and Coyote (1973–74). The relatively high use of Coyote may reflect predation, as well as scavenging on conspecifics. However, it may reflect auto-ingestion as well, as mange-infested coyotes lick and chew their own coats a great deal; an epizootic of sarcoptic mange was occurring in the coyote population at that time (Todd, Gunson and Samuel 1981).

In both habitats, consumption of Snowshoe Hares paralleled the cyclic decline in hare populations from *intermediate* to *scarce* levels during 1972–75, although the magnitude of the functional response was greater in the forest (Table 3). Todd and Keith (1983) showed a much broader range in hare use by forest Coyotes throughout Alberta as hares declined from *abundant* to *scarce* (from 67–23% volume in stomachs). Likewise, Todd, Keith, and Fischer (1981) showed that the biomass of hares in the winter diet of Coyotes in the primarily-forested area at Rochester ranged from 0 to 77% over a full cycle of hare abundance, largely (r^2 = 0.94) as a result of changing hare density.

As consumption of hares decreased, use of farm carrion, other native prey, and "other" foods generally increased in both habitats (Tables 2, 3). Field studies at Rochester (Todd, Keith, and Fischer 1981) showed that dietary shifts to and from consumption of Snowshoe Hares were accompanied by changes in habitat use over the course of the hare cycle; association with open agricultural habitats was inversely related to Snowshoe Hare abundance, as was proximity of Coyotes to graded roads and occupied dwellings. Demonstrated shifts in Coyote food habits throughout predominantly forested areas during the hare decline (Todd and Keith 1983; this study) suggest that such shifts in habitat use by Coyotes occur regionally as well. Earlier studies in Alberta presented limited evidence of movements between forest and farmlands (Todd and Keith 1976) and implicated changing hare abundance as a cause (Todd, Keith and Fischer 1981); this suggested limited availability of alternate foods in the forest during winters of hare scarcity (Todd and Keith 1983), which was corroborated by declines in indices to rates of food consumption by forest Coyotes during hare scarcity (Todd and Keith 1983; this study). Moreover, fat reserves of forest Coyotes tended to be lowest, particularly in late winter, and/or overwinter fat losses tended to be greatest, during years of hare scarcity (Todd and Keith 1983; this study). This was particularly so for renal and subcutaneous fat indices; trends in xiphoid fat weights showed aberrancies.

Although not evident in the present study, physical condition of Coyotes is doubtlessly affected by length and severity of winter. Compared to the Lynx (*Felis lynx*) or even the Coloured Fox (*Vulpes vulpes*), the foot-surface to body weight ratio of the Coyote is low (Todd and Keith 1976), which makes it prone to flounder in deep, uncrusted snow (Murie 1940; Ozoga and Harger 1966). Coyote hunting success on hares is reportedly low (Ozoga and Harger 1966; Berg and Chesness 1978), although Coyotes use the packed runways of expanding hare populations to advantage in hunting (Keith et al. 1977). Thus, although less affected as hares become abundant, Coyotes respond to increased snow depths by shifting from forested areas to open, agricultural habitats which are partly

swept free of snow by wind (Todd, Keith and Fischer 1981). Moreover, the greater compactness and bearing strength of snow in open areas (Formozov 1946) also facilitates travel by Coyotes. Another adverse effect on Coyotes of increased snow depths is that subnivean small mammals become unavailable (Todd and Keith 1976; Todd, Keith and Fischer 1981). However, a possible beneficial effect of snow depth is increased carrion from winter mortality of deer, which was above-normal during 1973–74 (Gunson 1979). Otherwise, winter conditions for Coyotes should have been severe in 1973–74 as snow cover was deeper, and more prolonged, and temperatures lower.

There was also evidence that Coyotes fed considerably on cereal grains lying unharvested in swaths during 1973–74 (Todd and Keith 1976:16–17). Due to heavy fall rains and early snows, a substantial portion of the 1973 grain crop in the parkland region was unharvested before winter. Cereal grain (seeds and straw) was the major component (> 50% volume) in the stomach contents of 33 Coyotes collected in 1973–74 (A. W. Todd, unpublished data). The volume of grain ranged from 100 to 655 ml in 19 stomachs, hence deliberate ingestion was unquestionable. Although oats predominated, wheat and rapeseed were sometimes encountered in large amounts.

Meadow Voles (*Microtus pennsylvanicus*) may have been a determinant of high fat reserves of Coyotes early during winter 1973–74. Dietary use of voles is often appreciable at vole population highs (Nellis and Keith 1976; Todd, Keith, and Fischer 1981). Although it is recognized that microtine abundance and trends may differ widely between districts, a snap-trapping index showed *Microtus* as being moderately abundant in fall 1973 at Rochester (Amamcik et al. 1979) and incomplete grain harvests made conditions generally favourable for the vole to increase.

It is clear from the present study that fat indices were generally higher, and that overwinter declines were often less in agricultural habitats than in forest during 1972–75. I believe observed differences in fat indices reflect the general greater abundance of available foods (farm carrion, garbage) and less adverse snow conditions in farmlands. Because of such important differences in winter ecology between habitats, I hypothesized that demographic parameters of Coyotes in agricultural habitats differed from populations in adjacent forest habitat during 1972–75, in spite of possible Coyote movements between habitats. Such movements, though possibly important in local Coyote population changes, are likely on a relatively small distance scale (Todd and Keith 1983).

Comparative Demography

Long-term indices to Coyote abundance in the agricultural habitats in this study are limited to (1) winter aerial counts on a 180-km^2 study area near Westlock, and (2) a night-lighting index during fall on roadside transects in the aspen parkland region in the border areas of Alberta and adjoining Saskatchewan. Except for a sharp increase during 1969–70, the overall tendency at Westlock has been one of relative stability during 1970–80 (Todd, Keith, and Fischer 1981; and A.W. Todd, unpublished data), particularly during 1975–80 when the average number of Coyotes counted overwinter (1–3 surveys/winter) has ranged only from 23 to 34 (A. W. Todd, unpublished data). Likewise, the overall trend in fall night-lighting counts has been one of stability during 1972–80, although the index has fluctuated irregularly between years from approximately 12–31 Coyotes/1600 km of transects (J. R. Gunson, unpublished data). The only long-term index in forest habitat is from aerial counts during winter on a 180-km^2 area near Rochester, which clearly shows Coyote numbers paralleling the 10-year cycle in Snowshoe Hares (Todd, Keith, and Fischer 1981; A. W. Todd, unpublished data). However, mean annual catches by registered trappers (Todd and Keith 1983) and trapper interview data (A. W. Todd, unpublished data) indicate cyclic changes in Coyote abundance throughout forested Alberta. Available index data thus suggest agricultural Coyotes increased or remained the same during 1972–74, while forest Coyotes declined about 2–4 fold.

Breeding rates and litter sizes in the forest appeared related to hare abundance (see also Todd, Keith, and Fischer 1981; Todd and Keith 1983) as well as winter severity, although there is a partial suggestion of inverse density-dependence. The pregnancy rate among adults declined from 1972 to 1973 (from 69 to 56%) and then increased markedly in 1974 (86%), after coyote numbers had declined appreciably (Todd, Keith, and Fischer 1981; Todd and Keith 1983). In contrast, breeding rates tended to remain constant in the farmlands, in line with apparent stability in Coyote numbers and food supply there, although litter sizes may have varied with winter severity.

Changes in reproductive performance in forest coyotes were of the same order of magnitude as reported by Todd and Keith (1983), even though this study did not span the full range in hare population abundance. That is not surprising however, as Todd and Keith (1983) concluded that important demographic changes did not occur until hares became scarce. In contrast, reproductive performance in farmland Coyotes (this study) was generally higher and less variable than in the forest, and approached levels reported by Nellis and Keith (1976) for the Rochester district during 1964–68. That supports the earlier contention (Todd, Keith, and Fischer 1981) that carcass analyses in the Rochester area included Coyotes that were little affected by hare population changes. Shifts in age structure accompanied changes in reproductive performance (see also Todd and Keith 1983) and were likewise less pronounced in agricultural habitats. Sex ratios were balanced except in the forest during 1972–

73, providing further possible evidence for stress-related changes in Coyote populations there.

Relative stability in numbers, physical condition, breeding rates, and age and sex structure of Coyotes in agricultural habitat is attributed to more favourable environmental conditions there, where farm carrion provides a continuing, accessible food supply in winter, and snow conditions are less adverse.

Acknowledgments

This study was supported by the University of Wisconsin College of Agricultural and Life Sciences, and the Research Committee of the Graduate School; the Alberta Fish and Wildlife Division, and Alberta Agriculture; the Research Council of Alberta; the Wisconsin Alumni Research Foundation; and the National Science Foundation. Assistance in the field, laboratory or with data analysis was provided by E. Anderson, C. J. Brand, P. M. Dwyer, D. Keith, R. Munstermann, D. Painter, J. L. Pease, D. M. Todd, E. Vowles, and L. A. Windberg. I thank J. R. Gunson, L. B. Keith and G. L. Storm for critical advice, and the hunters, trappers, and other persons who supplied coyote carcasses.

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Received 15 October 1983
Accepted 30 July 1984

Moult Chronology of American Wigeon, *Anas americana*, in Relation to Reproduction

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Wishart, Richard A. 1985. Moult chronology of American Wigeon, *Anas americana*, in relation to reproduction. Canadian Field-Naturalist 99(2): 172–178.

The moult chronology of American Wigeons (*Anas americana*) during their annual cycle in southwestern Canada was as follows: First-winter birds progressed asynchronously through the prealternate I moult but arrived on the breeding grounds in alternate I plumage. Adult males normally completed most of the prealternate moult by October. From January through April, adults underwent a partial moult of body contour feathers, which was more extensive in females than males. Males did not resume moult (prebasic) until after breeding, and most of it occurred following a moult migration to larger lakes and marshes in June and July. There, remiges were moulted simultaneously followed quickly by the prealternate moult before fall migration. Females underwent much of the prealternate moult (including down feathers) in late winter and during spring migration. Moult ceased during nesting in May and the prebasic moult did not occur until either nests failed (late June) or broods were abandoned (late July-August). Some females moulted on the breeding grounds, whereas others migrated to the same areas used by males. The moult chronology of individuals and sexes varies in relation to differences in their reproductive cycle.

Key Words: Moult, plumage, reproduction, annual cycle, American Wigeon.

The scheduling of moult varies in birds. Under different selection pressures, feather replacement occurs one to several times annually (Palmer 1972; King 1974). Because metabolic rate increases during feather replacement, moulting has evolved to reduce overlap with other energy-demanding processes such as migration, pairing, nesting and brood-rearing (Payne 1972; Dolnik and Gavrilov 1979; Bailey 1981).

Young ducks may undergo almost continuous moult through their first year (Oring 1968). However, some individuals moult earlier than others, which may influence their relative ability to compete for food, mates or breeding space (Wishart 1983a). Therefore, knowledge of the characteristics of moult is needed in order to understand the evolution of reproductive strategies.

Palmer (1976a) described American Wigeon (*Anas americana*) plumages and outlined schematically the timing of its moults. The observations here add details on aspects of wigeon moult and permit me to discuss the evolution of its chronology.

Methods

A sample of 191 American Wigeons was shot in 1976 to 1978 at study areas in British Columbia (January-April), Saskatchewan (April-August), and Manitoba (July-November) (Table 1). Plumage of each bird was examined for feather replacement and then plucked before other carcass analyses (Wishart 1979). The incidence of moult, as indicated by presence of blood-filled feather papillae, was recorded. Because flat skins were not made, detailed moult scores (Billard and Humphrey 1972) were not calculated. The stage of wing and tail moult was noted and the extent of body moult on other pterylae was described as heavy (> 50 papillae), moderate (10–50 papillae) or light (< 10 papillae). The length of sheathed primaries was also measured.

Additionally, 116 wigeons were live-trapped on those study areas using bait traps, nest traps, decoy traps and rocket nets, and birds were examined for moult before their marking and release. The plumage of 72 museum specimens was also examined for months (September-March) for which I had insufficient data for live birds. Forceps were used to fold back feathers of each pteryla to check for the presence of papillae.

Birds were aged using techniques described by Carney (1964) and Wishart (1981). Standard terminology was used to describe each age class (i.e., hatching-year = HY, second-year = SY, after-second-year = ASY and after-hatching-year = AHY).

Results

First-year birds

Southwick (1953) described the downy plumage of wigeons and the prejuvenal moult. Palmer (1976a) described the juvenal plumage and its replacement, which usually began before birds fledged.

In late August, the fledged HY birds I studied were moulting heavily on the body (prebasic I). Some birds shed rectrices in October but most did not do so until

TABLE 1. Number of American Wigeons studied for feather moult, by sex, age, month and location.[1]

Month	Study area[2]	Collected				Live-trapped				Museum specimens[3]				Total
		Males		Females		Males		Females		Males		Females		
		HY-SY	ASY-AHY	HY-SY	ASY-AHY	HY-SY	ASY-AHY	HY-SY	ASY-AHY	HY-SY	ASY-AHY	HY-SY	ASY-AHY	
January	1		2		1					2	3	2	2	12
February	1		9		4					2	4	2		21
March	1	2	21	2	7					3	3			38
April	2	6	13		10	2	3				6	2		42
May	2	1	12	6	7	6	18	4	2					56
June	2		8	3	12	1	1	5	5					35
July	2-3	2	12	3	15		1	9	5					47
August	2-3	3	6	3	7				1					20
September												2	1	3
October	3	5	1	4	3						1			14
November	3		1							5	9	4		19
December	1					6	18	12	17	12	4	3		72
Total		19	85	21	66	15	41	30	30	24	30	15	3	379

[1] HY-SY = first-year birds, ASY-AHY = adults.
[2] Study areas referring only to captured or collected specimens. 1 = Fraser River Delta, British Columbia (49°09′N, 123°01′W), 2 = Moose Jaw, Saskatchewan (50°15′N, 105°50′W), 3 = Delta Marsh, Manitoba (50°11′N, 98°19′W).
[3] Of 72 museum specimens, 51 from British Columbia, 4 from Manitoba, 8 from Ontario, 1 from New York, 6 from California, 1 from Utah and 1 from Louisiana. Specimens from Manitoba Museum of Man and Nature; University of Manitoba Zoology Museum; British Columbia Provincial Museum; Cowan Vertebrate Museum, University of British Columbia; Museum of Natural Sciences, National Museum of Canada; and Royal Ontario Museum.

December or January. Even by March three SY males had only replaced the four middle tail feathers and in April one female still had all notched juvenal rectrices (see Carney 1964).

The timing of the prealternate I moult varied among individuals. Several acquired alternate I plumage by October, except for a few basic I feathers conspicuous on the flanks, sides and crissum. Others did not reach that stage until six months later (see also Wishart 1983a). Males (drab colouration of females made them difficult to study) achieved alternate I plumage first on the head and neck, followed by the breast and flanks, and then the rump. Moult on the back, scapulars, and tail finished last. By the time birds returned to the breeding grounds in April, all I examined had attained alternate I plumage. However, the juvenal wing feathering remained until mid-summer (Wishart 1981).

Adult males

By October, AHY males had largely completed the prealternate moult (Table 2). However, as late as January some still retained a few basic feathers on the back, flanks and rump. From February through April a light to heavy moult (varied with individuals) occurred on the breast, tail coverts, back and scapulars. Plumage colouration was not altered and Billard and Humphrey (1972) called that a continuation of the prealternate moult in Greater Scaup (*Aythya marila*). In May there was little evidence of moult, but in June as their mates began to incubate, the prebasic moult began on head, breast, flanks, rump, tail and scapulars.

In early July, once pair bonds had broken, the prebasic moult continued as males congregated in small groups on larger wetlands. Within a week, those birds moved away from the breeding area (see also Hochbaum 1944; Salomonsen 1968; Bellrose 1976) to larger lakes and marshes where their moult continued. That may be a long movement for wigeons using such moulting areas as Swan Lake (Bergman 1973) and the Delta Marsh (Hochbaum 1944) in Manitoba, which are not near important breeding areas. In contrast, Old Wives Lake, Saskatchewan (50°07′N, 106°00′W), which was selected by moulting wigeons in preference to other adjacent waterfowl moulting areas (e.g., Pelican Lake and Chaplin Lake), was surrounded by a dense breeding population (Wishart 1983a), and movements there may involve only a few kilometers. Wigeon concentrations were highest on Delta and Old Wives Lake in June and July and then declined through August as the autumn migration began (see also Hochbaum 1944). Timing of that movement was delayed for males attending late nesting or renesting females (Wishart 1983a).

Before remiges were shed, birds attained almost full basic body plumage. However, rectrix moult was still incomplete when birds became flightless. The rectrices were not replaced in a fully consistent pattern, although central feathers were replaced first. Back feathers also were not moulted by that stage.

The first flightless male was collected on 11 July, and the majority of flightless birds were collected 15–31 July. One flightless male was collected on 20 August. Tertials were already sheathed when the

TABLE 2. Incidence of moult by adult male American Wigeons over their annual cycle.[1]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep[4]	Oct	Nov	Dec
Plumage[2]	A	A	A	A	A	A	B	B	A?	A	A	A
Moult[3]		A	A	A	B	B	B	A	A?	A	A	A
Head						+	+++	+++				+
Neck							+++	+++			+	
Breast		+	++	+	+	++	+++	+++			+	
Flanks						++	+++	+++		+	+	+
Rump						+	+++	+++				+
Tail						+	+++	+++				
Upper back			+	+			+	+++		+	+	+
Lower back			+	+			+	+++		+	+	+
Scapulars		+	+			+	++	++		+		
Tertials							+++	+++			+	
Tertial coverts								+++				
Primaries							+++	+++				
Secondaries							+++	+++				
Wing coverts							+++	+++				

[1]Rating based on intensity of moult on individuals (+ = light, ++ = moderate, +++ = heavy).
[2]Dominant plumage presently held by the bird. A = alternate, B = basic.
[3]Moult underway. A = prealternate, B = prebasic.
[4]No males examined.

primaries, secondaries and their coverts were shed. Underwing coverts were lost last. .

The tenth (P^{10}) was the first primary to reappear and the proximal secondaries proceeded the others. $P^{8,7,6,}$ and ^{5} were usually slightly longer than other ($P^{1,2,3,4,9}$ and ^{10}) primaries at early stages of feather growth (n = 7 males). However, because distal primaries ($P^{9,10}$) were longer at full size than proximal primaries, they (and occasionally also P^{5}) were last to have blood-free calami. At that stage the birds could fly.

While primaries were growing, some rectrices were still sheathed and moult on the spinal tract began. By the time flight was regained, spinal and body down moult was heavy and moult of rectrices was complete.

The prealternate moult began on the head and body in mid-August after the wing feathers were almost fully grown. Moult began first on the head, breast, rump, scapulars and flank.

Adult females

In January, adult females showed light moult on the anterior spinal tract and scapulars (Table 3). Through February and March the incidence of moult increased dramatically. That conformed to a continuation of the prealternate moult as described by Billard and Humphrey (1972). But in contrast to males, females underwent heavy moult on neck and head, and light moult on flank, rump and scapulars. This continued in March with heavy moult on breast, neck and head, and a moderate to light moult on the rump, tail, back and scapulars of some birds.

Adult females were still in light to heavy moult of contours on the head, neck, breast, back and scapulars after they had returned to the breeding grounds. A medium to heavy moult of down also occurred then. Rectrices and their coverts were also in full moult, although that ended during the breeding period in May and June.

No noticeable moult occurred in May when females were laying eggs. In June, females that lost nests began to replace down and contour feathers on the brood patch.

In July, the females I examined were in various reproductive stages (i.e., laying, incubating, brood-rearing and postreproductive). Laying and incubating birds and those in early brood-rearing showed little moult except for the replacement of two to eight median secondary coverts. Postreproductive females began the prebasic moult on breast, flanks, back, scapulars, sides, and on tail and tail coverts. A similar degree of moult occurred in late brood-rearing (young more than two weeks old) females, particularly those collected in August.

After six to seven weeks, wigeon females usually abandon their broods (see Beard 1964). At Moose Jaw those females, and possibly those unsuccessful at nesting, formed small flocks on larger ponds and ranged more widely over the area. Some then departed, presumably for the same lakes used by moulting males. Several moulting adult females were collected at the Delta Marsh although the concentration of males there was much greater. Not all females left the nesting area to moult as one flightless adult was captured with

TABLE 3. Incidence of moult by adult female American Wigeons over their annual cycle.[1]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov[4]	Dec
Plumage[2]	AB	AB	AB	AB	A	A	B	B	AB	AB	AB	AB
Moult[3]	A	A	A	A		B	B	A	A			
Head		+	+++	+++								
Neck		+	+++	+++				+++				
Breast			+++	+++		+++	+++	+++	+++			
Flanks		+					++	++				
Rump			+				++	++				
Tail		+	+	+++		+	+	++	+			
Upper back	+		++	++			++	++	++			
Lower back			++	++			++	++	++			
Scapulars	+	+	+	++		+	++	+	+			
Tertials							+	++				
Tertial coverts								++				
Primaries								+++				
Secondaries								+++				
Wing coverts							+	+++				

[1]Rating based on intensity of moult on individuals (+ = light, ++ = moderate, +++ = heavy).
[2]Dominant plumage presently held by the bird. A = alternate, B = basic.
[3]Moult underway. A = prealternate, B = prebasic.
[4]No females examined.

a six week old (age estimated following Gollop and Marshall 1954) brood on a permanent pothole in Saskatchewan on 11 August 1976. Because the birds were not marked I could not tell if the offspring were hers or had been abandoned by another female.

When the primaries were shed, the pattern of replacement was similar to that of males with middle primaries longer than those more proximal and distal. Again in one individual $P^{10, 9}$ and ^{5} were last to have calami clear of blood. When secondaries, coverts and primaries were ensheathed, moult was heavy on body pterylae. All rectrices and tail coverts were replaced also at that time. Prealternate moult was resumed and feather replacement was heavy on breast, tail, and back, into September. No signs of moult occurred in adult females in October through December (N = 3).

Discussion

Most northern Anatini males, including the American Wigeon, moult into alternate plumage (nuptial) in the late summer and fall. That is unlike many other species (see Dwight 1900; Palmer 1976a,b) which do not initiate that moult until just before spring migration and pairing. However, unlike most other species that renew their pair bonds annually, wigeon and most other North American ducks court and pair over the winter (Weller 1965; Wishart 1983b).

In American Wigeon, sex ratios favored males and some first-year birds paired and reproduced successfully (Wishart 1983a). Thus, there was competition for females, and adult wigeon males that had completed the prealternate moult were more successful in mate acquisition. Later-moulting adults and first-year males that only progressed gradually through the prealternate I moult rarely took part in courtship and frequently did not obtain mates (Wishart 1983b).

Even those males that completed the prealternate I moult early were not in definitive plumage because juvenal wing feathers were not replaced until the prebasic II moult. Thus, during their first courting and breeding season those birds lacked the white upper wing coverts which are displayed in courtship and antagonistic situations (Wishart 1981, 1983a). Males with that particular plumage fared poorly in competition for mates.

Adult males underwent a partial body moult in late winter. Oring (1968) believed that male Gadwalls (*Anas strepera*) that moulted at that time were replacing only a few feathers that were lost accidentally. However, feather replacement was too heavy for that to be a plausible explanation for wigeons (see also Billard and Humphrey 1972).

Compared to females, the winter moult by males was light and did not continue through migration. Visually, the alternate plumage colour patterns were not disrupted by that moult.

It is not adaptive for males to moult until females have started incubation. The added nutrient requirements for moult then would reduce the energy available for defense of his mate and territory. Colouration and mobility were also important for the male to fulfill these needs (Wishart 1983a) and these attributes would be reduced by moult.

Males replaced their alternate plumage starting in June, when it was badly worn and after the energetic demands of reproduction had ended. Once males were flightless they were almost completely in the dark cryptic basic plumage. Birds are inactive and secretive then (Hochbaum 1944; Young 1977) and that may reduce their vulnerability to predators (King 1974).

With flight resumed, vulnerability to predators would be lower and at that stage males began to replace their dull basic (eclipse) plumage. Although that feathering was still relatively unworn there are several advantages to its early replacement. Moult occurring in the warmth of late summer (Bergman 1973) would be less costly energetically than later, and there would be sufficient time for moult to end before fall migration (King 1974). When a male completed the moult he could begin competing for a mate and have a greater chance of acquiring one.

Unlike males, wigeon females completed much of the prealternate moult (including down and most rectrices) only in late winter and early spring. Little change in appearance was evident because the basic plumage, like the alternate, was cryptic. However, moult during winter and during migration is energetically demanding (King 1974). The advantage of that pattern in wigeon is unclear but may be related to the high energetic costs of reproduction and the extended period of brood care. Waterfowl depend on water for survival, and only a short interval is available for moult between brood abandonment and fall freeze-up. Thus there is an advantage to an interrupted moult in which part of the prealternate moult is accomplished after migration.

Moult during winter, by adult female ducks seems to be widespread in Anatini and Aythyini. It has been documented in Gadwall (Oring 1968; Paulus 1980), Mallard (*Anas platyrhynchos*) (Jorde 1981), European Wigeon (*Anas penelope*) (Palmer 1976; Cramp 1977), Redhead (*Aythya americana*) (Weller 1957, 1970) and Greater Scaup (Billard and Humphrey 1972). Erskine (1971, 1972) found no such evidence in Mergini. Jorde (1981) found that usually only after female Mallards paired did they undertake that moult. That could not be tested in wigeon because all females of known status collected in winter were paired.

The prealternate moult of female wigeon extended

through April. Most females did not nest before late May, or two to six weeks after the first birds had returned to the breeding grounds. Possibly that interval was necessary for renewing reserves used in the prior moult.

Moult in the wigeon female was interrupted by egg laying and was not resumed until the young were several weeks old. Through that interval, females stored nutrient reserves and then invested them in the eggs laid and incubated (Wishart 1983a). By the end of incubation females' weights were close to starvation levels (Wishart 1979, 1983a) and even a small increase in nutrient demand due to an earlier onset of moult could be critical to the survival of the female and her young (see Korschgen 1977; Ankney and MacInnes 1978).

Females that have reared broods begin the wing moult no earlier than August, up to two months behind the schedule of most males. However, because much of the prealternate moult occurred in late winter, the time and energy required for moulting before fall migration would be reduced. Despite that, females still lagged well behind males. Most males migrated in late August and early September, at a time when females and juveniles were still moulting or building up pre-migration nutrient reserves (see also Bellrose 1976).

The extent to which wigeon females remained sedentary or migrated to moult could not be established. Salomonsen (1968) believed that female dabbling ducks did not undergo a true moult migration as did males, but acknowledged that some did leave the breeding areas to moult. Gilmer et al. (1977) found that 42% of female Wood Ducks (*Aix sponsa*) and 39% of female Mallards completed the moult on their breeding areas. Chabreck (1966) reported that some female Gadwalls underwent the basic and prealternate moults after they had apparently reached their wintering grounds in Louisiana. The variability of that moult may be related to the breeding chronology and condition of females and possibly also to changes in weather and food conditions in different years (see Billard and Humphrey 1972).

Differences in time-energy budgets, particularly related to pairing, nesting and brood care (Wishart 1983a) between male and female wigeons are correlated with differences in their moult patterns. Comparative study of the moult of *Anas* spp. with differing reproductive strategies is needed to better interpret the relationship between moult and scheduling of reproductive events in the annual cycle (see Anderson and Batt 1982).

Acknowledgments

I am indebted to the Hill family for allowing me to live and work on their land and to W. G. Leitch who informed me of the Moose Jaw study area. M. L. Jungbauer-Wishart and C. A. C. Wishart provided technical assistance, and B. D. J. Batt, G. S. Hochbaum and G. Kaiser offered logistical help. Curators of museums mentioned in the text kindly allowed me to examine specimens in their care. I thank R. S. Palmer, M. G. Anderson, A. J. Erskine and S. G. Sealy for reviewing the manuscript, and P. Alvestad and M. Hilland for typing and editing. The work was funded through the Delta Waterfowl Research Station by the North American Wildlife Foundation, Canadian National Sportsmen's Fund and a Francis H. Kortright fellowship. Personal support came through scholarships from the Natural Sciences and Engineering Research Council of Canada, University of Manitoba and the Canadian Wildlife Service.

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Received 12 September 1983
Accepted 31 August 1984

Lichens of Eastern Axel Heiberg Island and the Fosheim Peninsula, Ellesmere Island, Northwest Territories

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Thomson, John W., and George W. Scotter. 1985. Lichens of eastern Axel Heiberg Island and the Fosheim Peninsula, Ellesmere Island, Northwest Territories. Canadian Field-Naturalist 99(2): 179–187.

One hundred and seventy-nine lichen taxa are listed from these high arctic islands: 149 from Axel Heiberg Island, 129 of them not previously listed; 99 from Ellesmere Island, 37 not previously listed. New to Canada are *Acarospora cartilaginea, Aspicilia cingulata, A. contigua, A. humboldtii, Buellia nivalis, Caloplaca alcarum, Lecidea sublimosa,* and *L. tenuissima*. New combinations are: *Aspicilia contigua* (Lynge) Thoms., *Aspicilia humboldtii* (Lynge) Thoms., and *Aspicilia nathorstii* (Lynge) Thoms. Three lichen parasites, *Discothecium gemmiferum, Rhabdospora lecanorae*, and *Tichothecium pygmaeum*, are also listed.

Key Words: Lichens, Axel Heiberg Island, Ellesmere Island, Northwest Territories.

As part of a natural resource survey, sponsored by Parks Canada, the second author made a collection of lichens from eastern Axel Heiberg Island and the Fosheim Peninsula of Ellesmere Island during July 1980. The lichen flora of that region is virtually unknown.

Study Area

The location of the collection area, east of the mountains of Axel Heiberg Island and west of the mountains of Ellesmere Island, is responsible for its "continental" type climate. The high ice-capped mountain ranges on Ellesmere Island present a barrier to the entry of mild, moist air from the North Atlantic. Similarly, the mountains of Axel Heiberg Island provide an effective barrier to maritime influences from the west. The climate of most islands of the Arctic Archipelago is influenced by the marine channels lying between them. However, Eureka Sound, Nansen Sound and Greely Fiord are never completely free of ice and therefore have little influence on the climate of the area.

The "continental" climate is characterized by warmer summers, colder winters and lower precipitation than experienced in maritime areas. Mean daily temperatures in the area range higher in the summer than other locations in the northern Arctic Archipelago. The warmer weather in the summer months accounts for the greater number of frost-free days at Eureka (66) compared to Alert (29) and Isachsen (27). The region is one of the driest regions in the world. The average annual precipitation at Eureka is 58.4 mm, 22.4 mm of that falling as rain.

A major factor influencing climate is the formation of a north-south oriented high pressure ridge in late winter. By April, this high pressure area spreads over the entire Arctic Archipelago and is associated with predominantly light winds and clear skies in April and May (Rae 1951). A drop in mean pressure occurs in June and July and low overcast stratus clouds are prevalent in the spring and summer months. Offsetting this is the fact that snowmelt is largely complete by this time throughout much of the archipelago and increased convection from solar heating of the ground surface results in a decrease in cloud cover (Rae 1951). The Eureka area receives less cloud cover than other locations in the archipelago, particularly in March, May and August. The region is subject to potentially continuous daylight from 15 April to 31 August. Fog and cloud cover is less frequent than other high arctic locations.

Roots (*in* Fortier et al. 1963) divided the area into two major physiographic subdivisions, the Ridged Uplands and the Eureka Sound Uplands. The Ridged Uplands consist of a range of mountains extending in a north-south direction. The ridges are often broad, widening into upland surfaces of irregular extent. A well-developed trellis drainage pattern is evident, with short, but fast-flowing creeks originating on the ridges at regular intervals. The valley walls are often steep and the steep mountains rising from the sea form spectacular scenery. The mountain chain is cut by Buchanan Lake, but it continues to the northwest with about the same altitude, but generally lowering relief. The highest peaks reach about 1300 m above sea level, occurring both northwest and southeast of Buchanan Lake. A few small, isolated icecaps occur on the highest peaks, but the ice accumulation is not sufficient to sustain glacier flows.

Eureka Sound Uplands area consists of generally low, but varied topography, drained by a well-developed dendritic pattern of streams. The major

streams originate in the glaciers reaching down from the mountains in the west. Three main physiographic elements can be recognized, occurring interspersed with one another: rolling uplands, low mountain ranges and broad lowlands. The main element in this physiographic unit is a rolling upland that occurs generally below the 300-m contour. The relief is generally less than 75 m, with broad valleys and low ridges although some streams may be incised to a greater depth. The rolling uplands are interrupted by low mountains that have peak elevations between 550 m and 840 m. These areas may consist of single peaks, or mountainous chains up to 25 km long. Although the elevations are not high, steep rocky cliffs are abundant. The third element of this physiographic unit is characterized by low relief. Flat, featureless plains extend for long distances south of Schei Peninsula and in other low-lying areas. Poorly drained lowlands, some with small ponds are frequent.

Most of the area is stratigraphically in the sedimentary Sverdrup Basin, and structurally within the Eureka Sound fold belt (Fortier et al. 1963). The stratigraphic units range from the Permo-Carboniferous, through the Mesozoic into the Tertiary and constitute a conformable sequence of marine and non-marine deposits. Volcanic basic flows are of Permo-Carboniferous and Cretaceous ages. All formations were folded simultaneously and the orogeny took place in the Tertiary, as even the early Tertiary Eureka Sound formation was folded along with the older formations. Gypsum of Permo-Carboniferous age was deformed and intruded into younger rocks following the intense period of orogeny during the Tertiary. The geology of the area was intensively studied in the 1950s and 1960s and details are available in reports by Fortier et al. (1963), Tozer (1963), and Thorsteinsson (1974) and maps by Thorsteinsson (1971a, 1971b), and Thorsteinsson and Trettin (1972).

Permafrost underlies all land surfaces. The thickness of the frozen layer is not known, but it certainly amounts to several hundreds of metres. The ice content of the permafrost is variable. Ice-rich permafrost is found near the surface in fine-grained soils having imperfect to poor drainage. The seasonally thawed surface layer, the active layer, varies in thickness at its maximum development according to different soil materials and vegetation cover.

Intensive frost action and numerous freeze-thaw cycles initiate processes in the ground that result in frost heaving and churning of the soil (cryoturbation). Various surface forms attributed to frost action, such as earth hummocks, mudboils, mini-mounds and upland and lowland polygons, are common in the area.

Soil parent materials include glacial till, colluvium, marine deposits and alluvium. All soils belong to the Cryosolic Order, as permafrost occurs within 1 m of the surface everywhere. Both Turbic and Static Great Groups are present.

The vegetation of the area is dominated by polar semi-desert community types, with local areas of arctic tundra. The composition of the flora reflects high arctic elements, with a representation of low arctic species. Vegetation types include dwarf shrub with *Dryas* barren and barren heath subtypes, dwarf shrub-sedge, sedge with sedge meadow and seepage slope subtypes, dry steppe and upland seepage.

Latitudes, longitudes, elevations in meters (asl) and dates at the collection sites were as follows:

Axel Heiberg Island

A-1	79°54′N, 87°43′W	75 m	19 July 1980
A-2	80°02′N, 88°45′W	175 m	19 July 1980
A-3	80°01′N, 88°48′W	140 m	19 July 1980
A-4	80°07′N, 88°12′W	30 m	19 July 1980
A-5	80°17′N, 88°27′W	215 m	19 July 1980
A-6	80°24′N, 87°38′W	6 m	19 July 1980
A-7	80°11′N, 87°46′W	135 m	19 July 1980
A-8	79°49′N, 87°32′W	45 m	20 July 1980
A-9	79°46′N, 87°18′W	530 m	20 July 1980
A-10	79°41′N, 87°31′W	120 m	20 July 1980
A-11	79°41′N, 87°25′W	135 m	20 July 1980
A-12	79°38′N, 87°27′W	665 m	20 July 1980
A-13	79°37′N, 87°42′W	275 m	20 July 1980
A-14	79°33′N, 87°32′W	195 m	20 July 1980
A-15	79°27′N, 87°38′W	90 m	21 July 1980
A-16	79°15′N, 87°43′W	355 m	21 July 1980
A-17	79°05′N, 87°22′W	410 m	21 July 1980
A-18	79°14′N, 86°10′W	165 m	21 July 1980
A-19	79°22′N, 86°15′W	90 m	21 July 1980
A-20	79°39′N, 89°42′W	1220 m	22 July 1980
A-21	79°46′N, 88°46′W	410 m	22 July 1980
A-22	79°35′N, 87°23′W	8 m	22 July 1980
A-23	79°20′N, 86°38′W	180 m	22 July 1980
A-24	79°15′N, 85°30′W	145 m	22 July 1980

Ellesmere Island

E-1	79°59′N, 85°50′W	6 m	16–18 July 1980
E-2	79°43′N, 85°50′W	150 m	20 July 1980
E-3	80°06′N, 85°37′W	135 m	22 July 1980
E-4	80°12′N, 85°12′W	105 m	22 July 1980
E-5	81°06′N, 85°51′W	6 m	22 July 1980
E-6	81°00′N, 84°50′W	150 m	22 July 1980
E-7	80°49′N, 85°55′W	455 m	22 July 1980
E-8	80°03′N, 85°30′W	760 m	22 July 1980
E-9	79°52′N, 85°10′W	30 m	24 July 1980

The first set of voucher specimens were deposited in the herbarium, University of Wisconsin, Madison

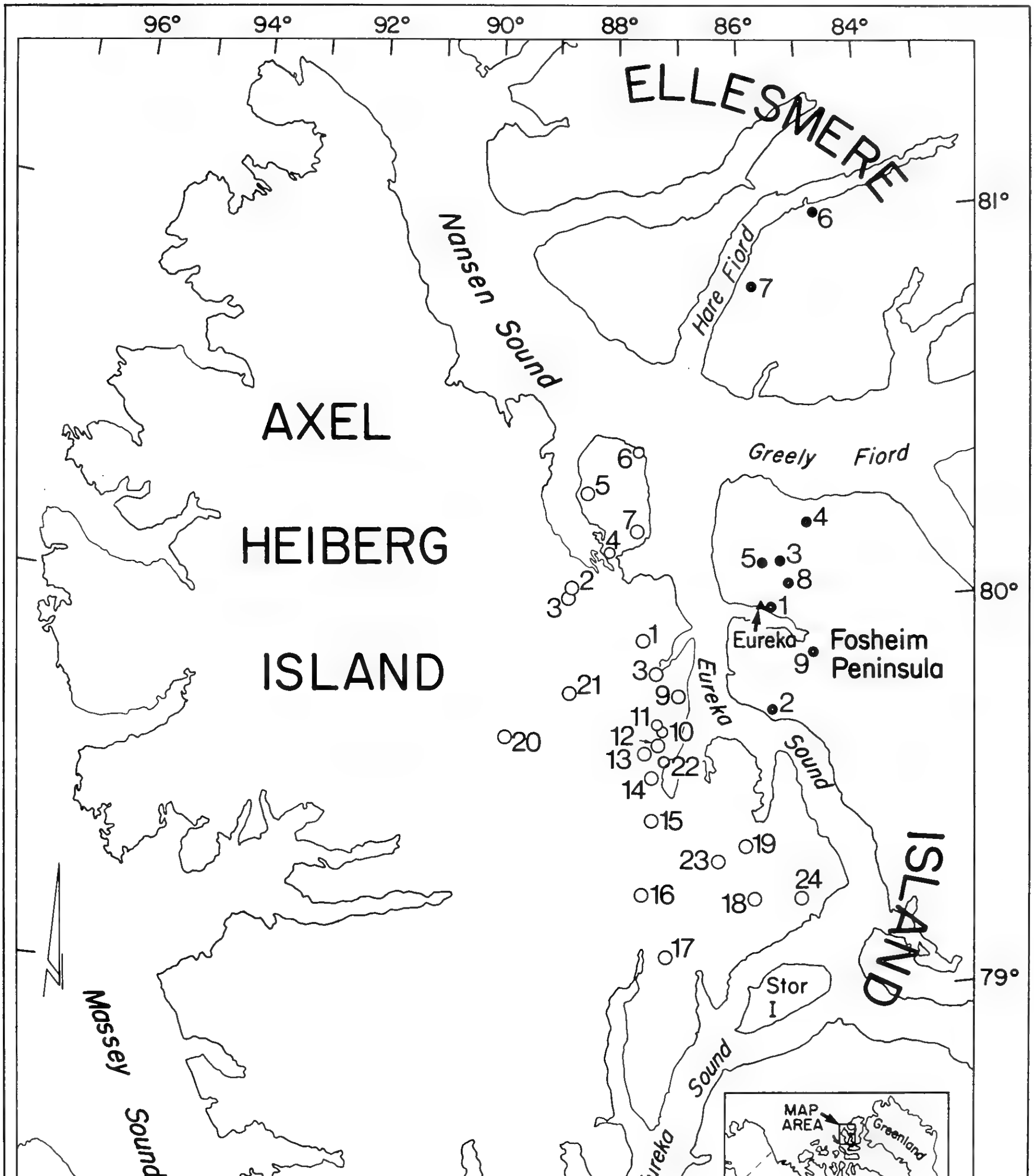

FIGURE 1. Map of the collection sites. Those with open circles on Axel Heiberg Island are prefixed with A in the listings; those with closed dots on the Fosheim Penninsula are prefixed with E in the listings.

(WIS). Some duplicates were deposited in the herbarium of the Canadian Forestry Service, Edmonton (CAFB). All identifications were by J.W. Thomson.

Previous Investigations

Early records of lichens from Ellesmere Island have been summarized by Lynge (1947) in his paper on the lichens of the Canadian Eastern Arctic. The earliest paper of note, based on the collections made on the English Polar Expedition of 1875–76, was written by T. M. Fries (1879). The Ellesmere Island collections were made along the east coast in the sections then called Ellesmere Land, Grinnell Land, and Grant Land. Fries listed 102 lichens, several new to science, including *Parmelia (Xanthoparmelia) separata, Caloplaca celata, Lecidea scrobiculata, Lecidea despecta, Lecidea ultima, Microglaena sordidula, Verrucaria phleothelena*, and *Microthelia melanostoma*.

During the Lady Franklin Bay Expedition of 1881–1884 only seven lichens were collected (Lehnert and Greely 1888) and these were determined by Lehnert. A very large number of lichens were collected during the "Fram" Expedition of 1898–1902. They were reported upon by Darbishire (1909) but the quality of the determinations was severely criticized by Lynge (1947) and the material has not been restudied. Eight species were described as new to science: *Lecidea purissima (= Lecidea marginata* Schaer. according to Hertel 1967), *Lecidea solitaria, Catillaria sanguinaria, Catocarpon depressum (= Rhizocarpon chioneum), Pertusaria determinanda (= Pertusaria subplicans* Nyl.) *Placodium splendens, (= Xanthoria elegans* var. *splendens), Aspicilia lesleyana*, and *Aspicilia nikrapensis (= Lecanora candida* var., *nikrapensis* (Darb.) Magn. = *Aspicilia candida* (Anzi) Hue). Darbishire's list is composed of other arctic records as well as the material from Ellesmere Island. Of the 495 species listed only 158 are actual records from Ellesmere Island, and three are also from Axel Heiberg Island. Schuster, Steere and Thomson (1959) listed 108 species, including 113 taxa, from the north end of Ellesmere Island. Powell (1967) added records of 38 lichens from the Lake Hazen area in the interior of northern Ellesmere Island.

Axel Heiberg Island is poorly represented in previous reports. Thomson (1960) included three species collected by A. Innes-Taylor on the island as well as 20 species from Ellesmere Island. These are in CANL. Marian Kuc collected 21 species at Good Friday Bay, southern Axel Heiberg, in 1957 and reported on them in 1969. Kuc made a much more intensive collection at the head of Expedition Fiord near White Glacier, 91°45′N, 79°25′W, but these have not been reported on and are filed at CANL with some duplicates at WIS. Thus the majority of the species reported here are new for that island.

List of Species:

*indicates new to Ellesmere Island.
†indicates new to Axel Heiberg Island.

+*Acarospora cartilaginea* Magn. A23(*46448*). This species was described from Greenland and is new to North America. Like *A. fuscata* it is a brown species with a C+ red reaction of the cortex and a dark underside. The hymenium is higher, 100–135 μ, instead of the 85–100 μ in *A. fuscata*. The cortices as described by Magnusson are very comparable, 30–40 μ in this, 25–50 μ in *A. fuscata*. Quite possibly this species represents only an extreme in the ambit of *A. fuscata*.

+*A. chlorophana* (Wahlenb.) Mass. A20 (*46417*).

+*A. fuscata (Nyl.) Arn. A14 (46365)*.

+*A. peliocypha* (Wahlenb.) Arn. A14 (*46378*).

**A. pyrenopsoides* Magn. E1 (*46457*).

+*A. scabrida* Hedl. A14 (*46367*).

+*A. veronensis* Mass. A4 (*46306*).

Alectoria nigricans (Ach.) Nyl. A2 (*46023*), A16 (*46142*), A18 (*46173*), A21 (*46187*), E1 (*46236*), E2 (*46241*).

A. ochroleuca (Hoffm.) Mass. A2 (*46030*), A5 (*46083*), E1, (*46237*), E8 (*46268*).

**Aspicilia alpina* (Sommerf.) Arn. E8 (*46537*). The specimen is a sterile thallus but has the appearance and chemical reactions of this species, I + blue, K + red and containing norstictic acid in o-T test.

*+*A. anseris* (Lynge) Thoms. A4 (*46302*), A14 (*46374*), A23 (*46437*), E1 (*46458*), E6 (*46524*).

+*Aspicilia arctica* (Lynge) Oxner. Site A21 (*46427*).

*+*Aspicilia cingulata* (Zahlbr.) Oxner. Sites: A4 (*46308*), A6 (*46331*), A7 (*46333*), A14 (*46376, 46377*), A23 (*46433*), E1 (*46454*). In *Aspicilia cingulata* there is a more or less continuous thallus with a flattened continuous orbicular, zonate appearance. Over this are bordering radiating elongated areolae which are more or less contiguous. Centrally the areolae are shorter and more angular. Excellent habit photographs are in Zahlbruckner (1928) in Plate I, Figure 2 (sub *Lecanora plicigera*) and Plate II, Figure 2. The thallus color is a brownish or yellowish gray and the reaction with K is negative. The paraphyses are non moniliform in this species. This species was previously known from Novaya Zemlya, Alaska, Bylot Island, and northern Baffin Island, and is probably circumpolar high Arctic.

+*Aspicilia contigua* (Lynge) Thoms. comb. nov. Basionym: *Lecanora contigua* Lynge, Skrifter om Svalbard og Ishavet 81: 93. 1940. A2 (*46295*), A4 (*46313*). *Aspicilia contigua* has a similar aspect to *A. cingulata*, that is a thin generally zonate hypothallus over which lie radiating areolae. In the latter species the radiating areolae are touching

each other, whereas in *A. contigua* they are separate with spaces between the "lobing" so that they appear more discrete. The paraphyses in *A. contigua* are moniliform. *Lecanora circularis* Magn. differs in having larger apothecia, 0.5–1.2 mm vs. 0.3–0.4 mm and the marginal lobate areolae about 0.5 mm rather than 0.2 mm. These may however represent phases of the same species. *A. contigua* is illustrated in Lynge (1940) Plate VI, Figure 1. These species are also very similar in appearance to *Aspicilia perradiata* (Nyl.) Hue which, however, has a K+ yellow reaction on account of an atranorin content.

A. flavida (Hepp) Rehm. E1 (*46484*), E2 (*46500*).

+*Aspicilia humboldtii* (Lynge) Thoms. comb. nov. Basionym: *Lecanora humboldtii* Lynge, Skrifter om Svalbard og Ishavet 81: 97. 1940. A4 (*46314*). This species is another of the Orbiculares group of *Aspicilia* with radiate areolae over a dark hypothallus and a K-reaction. It is distinguished by its large areolae 1.1.5 mm broad in the central thallus, to 0.35 mm in the marginal lobes, a high hymenium 125 μ, thick cortex 50–60 μ and large spores 20–25 $\times$ 10–15 μ. This species was previously known only from the type locality Cape Humboldt in northeast Greenland. It is illustrated in Lynge (1940) Plate VIII, Figures 1 and 2.

A. lesleyana Darb. All (*46337*).

**Aspicilia nathorstii* (Lynge) Thoms. comb. nov. Basionym: *Lecanora nathorstii* Lynge, Skrifter om Svalbard og Ishavet 81: 83. 1940. Site E1 (*46350*). This species belongs in the Effusae section of *Aspicilia* as it lacks marginal radiation of its areolae. Its spores are small, 14–22 $\times$ 8–13 μ, the hymenium low, 75 μ, and the thallus reported as slightly roseate by Lynge seems only grayish white. The areolae are indistinct in the type specimen which is illustrated in Lynge (1940) Plate II, Figure 1.

A. nikrapensis Darb. E2 (*46497*), E6 (*46516*). This lichen is also placed as *Lecanora candida* var. *nikrapensis* (Darb.) Magn. or *Aspicilia candida* var. *nikrapensis* (Darb.) Oxner, Nov. Syst. Pl. non Vasc. 19: 287. 172. It has in addition been called *Lecanora lyngei* Zahlbr. and under that name illustrated in Zahlbruckner (1928) Plate II, Figure 1. It has only slightly radiate marginal areolae, a rather thick thallus usually, and pruinose disks with a markedly black border. The thallus is very soft chalky.

A. perradiata (Nyl.) Hue E1 (*46469*), E2 (*46486*).

A. plicigera (Zahlbr.) Räs. A23 (*46444*).

**A. rosulata* Körb. E1 (*46451*).

+*Bryoria chalybeiformis* (L.) Brodo & Hawksw. A2 (*46017*), A18 (*46172*).

+*B. nitidula* (Vain.) Brodo & Hawksw. A2 (*46033*).

Buellia alboatra (Hoffm.) Tuck. E1 (*46470*).

B. geophila (Sommerf.) Lynge E7 (*46263*).

+*B. leptocline* (Flotow) Körb. A21 (*46431*).

+*B. nivalis* (Bagl. & Carest) Hertel ex Hafellner (*Polyschistes nivalis* (Bagl. & Carest) Keissl. Growing on *Xanthoria elegans*. This rarely noted species has previously been reported from the Alps and the Scandinavian mountains in Europe, from Novaya Zemlya and Greenland. Hertel reported it from Alaska from collections on *Xanthoria sorediata* at the Pitmegea River, Thomson 10 571. It may be recognized by the necrotic areas it causes on the host. The spores are 3-septate to muriform. It was found at site A14 (*46380*). New to Canada.

+*B. papillata* (Sommerf.) Tuck. A2 (*46028*), A5 (*46070*), A11 (*46122*), A13 (*46139*), A21 (*46179*), E1 (*46222*), E3 (*46249*).

+*B. stigmatea* Körb. On caribou antler, A1 (*46389*).

+*Caloplaca alcarum* Poelt. On sandstone, A14 (*46348*). This species, published by Poelt in a paper on the lobate species of *Caloplaca* in Europe (Mitt. Bot. Staatss. München 11: 11-31. 1954) on page 25 is equivalent to *Caloplaca murorum* var. *obliterata* Vain. in the sense however of Lynge. It produces small thalli usually covered densely by apothecia and with but few short bordering lobes. It actually differs from *C. murorum* var. *obliterata* in producing slightly larger spores 10.5–14 $\times$ 4.5–8 μ instead of 8–16 $\times$ 2.5–7 μ with the septum more definite than the poorly developed septum of *C. murorum.* The paraphyses tips are 6 μ instead of the 7–9 μ *C. murorum.* This species was previously described from Novaya Zemlya in the Arctic and is a species associated with bird dunging. A photo is provided in Lynge (1928) Plate X, and drawings of spores and a paraphysis are in Plate 5, Figures 32–34.

+*C. cinnamomea* (Th. Fr.) Oliv. A2 (*46038*), A4 (*46059*).

*+*C. festiva* (Ach.) Zwack. On caribou antler, A1 (*46285*), E1 (*46482*).

**C. invadens* Lynge. E2 (*46488*).

+*C. stillicidiorum* (Vahl) Lynge A1 (*46287*), A2 (*46037*), E1 (*46231*).

+*C. tetraspora* (Nyl.) Oliv. A2 (*46013*), A4 (*46062*), A17 (*46158*).

+*C. tiroliensis* Zahlbr. A1 (*46283*), A2 (*46049*), A3 (*46049*), A5 (*46086*), A17 (*46150*), E1 (*46201*), E3 (*46251*), E7 (*46259*).

+*Candelariella aurella* (Hoffm.) Zahlbr. On caribou antler and rocks. A1 (*46281*), A14 (*46355*).

C. dispersa (Räs.) Hakul. On thallus of *Placynthium aspratile.* E6 (*46512*).

+*C. terrigena* Räs. A2 (*46012*), A4 (*46058*), A5

(*46066*), A16 (*46144*), A17 (*46157*), A23 (*46194*).
Cetraria cucullata (Bell) Ach. A2 (*46040*), A16 (*46140*), E1 (*46220*).
C. delisei (Bory) Th. Fr. A5 (*46063*), A12 (*46124*), E9 (*46273*).
+*C. fastigiata* (Del. ex Nyl. in Norrl.) Kärnef. A5 (*46084*), A9 (*46100*).
C. nivalis (L.) Ach. A5 (*46072*), A7 (*46093*), A10 (*46112*), A11 (*46113*).
Cladonia amaurocraea (Flörke) Schaer. A7 (*46094*).
+*C. cariosa* (Ach.) Spreng. A5 (*46078*).
+*C. coccifera* (L.) Willd. A2 (*46016*), A17 (*46167*).
+*C. macrophylla* (Schaer.) Stenh. A6 (*46089*).
+*C. pocillum* (Ach.) O. Rich. A2 (*46018*), A5 (*46064*), A9 (*46098*), All (*46118*), E1 (*46238*), E7 (*46266*).
+*C. pyxidata* (L.) Hoffm. A18 (*46176*).
*+*Collema bachmanianum* (Fink) Degel. A18 (*46177*), E1 (*46217*). This is a considerable extension of the range northeastward from the previously known arctic sites at Coppermine and Churchill.
+*C. tenax* (Sw.) Ach. A4 (*46057*).
Cornicularia aculeata (Schreb.) Ach. E1 (*46210*).
+*C. divergens* (Ach.) Ach. A2 (*46031*), E8 (*46270*).
+*C. muricata* (Ach.) Ach. A3 (*46044*), A5 (*46075*), E7 (*46262*).
D. ramulosa (Hook.) Nyl. A17 (*46164*), E9 (*46272*).
+*Dermatocarpon lachneum* (Ach.) A.L. Smith. A10 (*46111*).
*+*Evernia perfragilis* Llano A4 (*46051*), E1 (*46198*).
+*Fulgensia bracteata* (Hoffm.) Räs. A2 (*46014*), A10 (*46110*), A12 (*46126*), A18 (*46168*), E1 (*46224*), E3 (*46245*), E9 (*46274*).
+*Glypholecia scabra* (Pers.) Müll. Arg. A4 (*46315*). This is a rare species better known from western North America, including Alaska and the Anderson River, N.W.T.
Huilia macrocarpa (DC.) Hertel. E1 (*46456*).
+*Hypogymnia subobscura* (Vain.) Poelt. A10 (*46108*), All (*46119*), A18 (*46171*), A21 (*46183*), E1 (*46213*), E7 (*46257a*).
**Ionaspis epulotica* (Ach.) Th. Fr. var. *arctica* (Lynge) Magn. E1 (*46468*), E8 (*46541*).
+*Lecanora atrosulphurea* (Wahlenb.) Ach. A23 (*46432*). det. by H. Vänskä.
*+*L. badia* (Pers.) Ach. A16 (*46390*), E8 (*46529*).
*+*L. cenisia* Ach. A16 (*46402*), E2 (*46490*).
L. cladonioides Lynge E2 (*46502*).
+*L. congesta* Lynge A14 (*46369*). A rare high arctic species known from Greenland and Ellesmere Island.
+*L. crenulata* (Dicks.) Nyl. A1 (*46288*), A7 (*46336*), A14 (*46350*).
+*L. dispersa* (Pers.) Sommerf. A1 (*46286*).
+*Lecanora epibryon* (Ach.) Ach. A2 (*46039*), A5 (*46073*), A7 (*46096*), A16 (*46148*), A17 (*46159*), E1 (*46207*), E3 (*46250*).
*+*L. groenlandica* Lynge A14 (det. uncertain), E2 (*46511*).
**L. occidentalis* (Lynge) Lynge E2 (*46498*). A rare species known from Greenland, Hudson's Bay, and the Alps in Europe (Poelt 1975). The epithecium and upper hymenium of this have an unusual K+ bluish reaction.
*+*L. palanderi* Vain. A5 (*46082*), E1 (*46200*).
+*L. polytropa* (Ehrh.) Rabenh. A2 (*46296*), A11 (*46345*), A14 (*46358*), A21 (*46429*), A23 (*46439*), E1 (*46462*), E2 (*46491*), E6 (*46517*).
+*L. rupicola* (L.) Zahlbr. A18 (*46124*), A21 (*46419*).
+*L. superfluens* Magn. A13 (*46130*).
**L. torrida* Vain. E1 (*46466*), E2 (*46505*).
+*Lecidea* sp. Site A23 (*46445*). The specimen possibly represents an undescribed species. It has a very tiny dark gray thallus, radiate, K-, C- I+ blue. The excipular margin is thin and black with its interior purplish brown and radiate, the subhymenium hyaline and inspersed, the epithecium green black, the paraphyses subcapitate, the spores $15 \times 6\ \mu$. Growing on rock.
+*Lecidea arctogena* Th. Fr. A20 (*46414*), A23 (*46434*).
*+*L. armeniaca* (DC.) Fr. A16 (*46393*), E8 (*46538*).
+*L. assimilata* Nyl. A2 (*46008*), A5 (*46076*), A16 (*46146*), A17 (*46154*).
**L. atromarginata* Magn. E2 (*46499*).
L. auriculata Th. Fr. A16 (*46391*), A23 (*46440*), E1 (*46452*), E8 (*46533*).
+*L. brachyspora* Th. Fr. A16 (*46388*). This is a rare species. Hertel (1977) has a map in which it appears in the vicinity of Lake Athabasca. He later reported it from Alaska on the basis of a specimen collected by Thomson. Otherwise it has been reported from Europe and Spitzbergen. Fries (1879) reported it from Floeberg Beach, Grant Land.
+*L. confluens* (Web.) Ach. A4 (*46305*), A6 (*46326*), A16 (*46392*).
+*L. cuprea* Sommerf. A12 (*46128*).
+*L. glaucophaea* Körb. A6 (*46329*).
+*L. lapicida* (Ach.) Ach. A7 (*46335*), A16 (*46405*), A21 (*46428*), A23 (*46446*), E1 (*46477*).
*+*L. limosa* Ach. A3 (*46048*), A5 (*46074*), E9 (*46277*).
+*L. lulensis* (Hellb.) Th. Fr. A20 (*46412*), E8 (*46530*). This specimen is close to f. *epichlora* Vain. as the epithecium and upper hymenium are blue.
*+*L. marginata* Schaer. A2 (*46293*), A4 (*46307*), A5 (*46317*), A14 (*46360*), A16 (*46401*), A21 (*46430*), A23 (*46438*), E1 (*46453*).
L. paupercula Th. Fr. E8 (*46536*).
+*L. picea* Lynge A2 (*46294*), E8 (*46527*).
+*L. ramulosa* Th. Fr. A5 (*46071*), A9 (*46102*), A12

(*46217*), A21 (*46191*), E9 (*46278*).

**L. sublimosa* Nyl. E1 (*46208*). This species appears to be new to North America. It was described from Lawrence Bay on the Bering Straits and is known from Novaya Zemlya and Lapland in Sweden. It resembles *L. limosa* but has a varnish-like thallus, hyaline hypothecium, and larger spores 18–25 × 8–9 μ. The hymenium is lower, 65 rather than 100 μ.

+*L. tenuissima* Lynge A18 (*46175*). The hypothecium and exciple are beautifully violaceous as described by Lynge. This is the second report for this species described from Greenland.

+*L. tessellata* (Ach.) Flörke A2 (*46297*), A11 (*46343*), A16 (*46387*), E1 (*46467*), E2 (*46506*), E6 (*46519*).

**L. tessellata* var. *caesia* (Anzi) Arn. E1 (*46463*).

**L. ultima* Th. Fr. E1 (*46476*).

*+*L. umbonata* (Hepp) Hertel A23 (*46447*), E2 (*46504*).

+*L. vorticosa* (Flörke) Körb. A14 (*46357*), E6 (*46522*).

**Lecidella spitzbergensis* (Lynge) Hertel & Leuck. E6 (*46523*). Hertel (1970) reported this rare arctic alpine species from Alberta and Wyoming. It is also known from Europe, Iran, and China as well as Spitzbergen.

+*L. stigmatea* (Ach.) Hertel & Leuck. A1 (*46279*), A2 (*46300*), A6 (*46330*), A11 (*46342*), A14 (*46361*), A16 (*46386*), A20 (*46415*), A21 (*46424*), E1 (*46455*), E2 (*46495*), E6 (*46520*), E8 (*46534, 46535*).

+*L. wulfenii* (Hepp) Körb. A3 (*46047*).

+*Leciophysma finmarkicum* Th. Fr. A2 (*46027*).

+*Lepraria arctica* Lynge A13 (*46135*).

+*Leptogium arcticum* Jörg. A2 (*46035*).

L. lichenoides (L.) Zahlbr. E1 (*46227*).

+*L.* cf. *tenuissimum* (Dicks.) Fr. A17 (*46161*).

**Massalongia carnosa* (Dicks.) Körb. E1 (*46204*), E7 (*46261*).

Neuropogon sulphureus (Koenig) Hellb. E8 (*46269*).

+*Ochrolechia frigida* (Sw.) Lynge A13 (*46129*), A16 (*46147*), A17 (*46162*), E1 (*46203*), E7 (*46256*); E9 (*46275*).

+*O. upsaliensis* (L.) Mass. A17 (*46163*).

*+*Omphalodiscus decussatus* (Vill.) Schol. A5 (*46321*), A6 (*46328*), A16 (*46395*), A23 (*46441*), E2 (*46424*), E8 (*46271*).

**O. krascheninnikovii* (Sav.) Schol. E2 (*46243*).

+*O. virginis* (Schaer.) Schol. A4 (*46054*), A5 (*46065*), A11 (*46120*), E2 (*46492*), E7 (*46260*).

+*Pachyospora verrucosa* (Ach.) Mass. A5 (*46081*), A13 (*46133*), A21 (*46186*), E1 (*46206*), E7 (*46255*). The report of *Pertusaria freyi* var. *monosticha* in Schuster, Steere, Thomson (1959) is an error based on this species.

*+*Parmelia elegantula* (Zahlbr.) Szat. (*Melanelia elegantula* (Zahlbr.) Essl.). A14 (*46366*), A23 (*46193*), E1 (*46230*), E7 (*46258*).

P. infumata Nyl. (*Melanelia infumata* (Nyl.) Essl.) A11 (*46123*), A17 (*46166*).

+*P. omphalodes (L.) Ach. A17 (46165)*, A18 (*46170*).

Peltigera aphthosa (L.) Willd. A1 (*46003*), A2 (*46010*), A3 (*46046*), A5 (*46067*), A9 (*46103*), A13 (*46103*), A17 (*46156*).

+*P. canina* (L.) Willd. A9 (*46097*), A11 (*46114*), E1 (*46225*), E7 (*46264*).

+*P. canina* var. *rufescens* (Weis.) Mudd A3 (*46043*), A9 (*46104*), A13 (*46138*), A17 (*46153*), A21 (*46182*).

+*P. occidentalis* (Dahl) Krist. A2 (*46024*). This is a rare species known currently from Iceland, Greenland, and Bathurst Inlet, N. W. T., as well as this specimen from Axel Heiberg Island. A report from Alberta was based on a misidentification.

+*P. polydactyla* (Neck.) Hoffm. A9 (*46109*).

+*Pertusaria coriacea* (Th. Fr.) Th. Fr. A2 (*46007*), A5 (*46077*), A6 (*46091*), A9 (*46099*), A23 (*46195*), E1 (*46209*).

+*P. dactylina* (Ach.) Nyl. A17 (*46149*), A21 (*46185*).

+*P. panyrga* (Ach.) Mass. A5 (*46087*), A7 (*46095*).

+*Phaeorrhiza nimbosa* (Fr.) Mayrh. & Poelt A2 (*46042*), E1 (*46233*).

+*Physcia caesia* (Hoffm.) Hampe A1 (*46280*), A2 (*46301*), A13 (*46131*), A14 (*46346*), E1 (*46214*), E6 (*46514*), E7 (*46254*).

+*P. dubia* (Hoffm.) Lettau A2 (*46026*), A4 (*46061*), E1 (*46214*).

+*Physconia muscigena* (Ach.) Poelt A2 (*46009*), A3 (*46050*), A4 (*46052*), A11 (*46115*), A13 (*46136*), A21 (*46189*), E1 (*46221*), E3 (*46247*), E7 (*46257b*), E9 (*46276*).

+*Placopsis gelida* (L.) Lindsay A11 (*46344*), A14 (*46353*).

Placynthium aspratile (Ach.) Henss. E6 (*46512*).

+*Pseudephebe minuscula* (Nyl. ex Arn.) Brodo & Hawksw. A5 (*46319*), A21 (*46425*), A23 (*46436*), E2 (*46240*), E8 (*46526*).

P. pubescens (L.) Choisy A2 (*46032*), A5 (*46318*), E8 (*46525*).

+*Psora rubiformis* (Ach.) Hook. A1 (*46000*), A11 (*46117*).

+*Psoroma hypnorum* (Vahl) S. Gray A17 (*46155*).

+*Rhizocarpon badioatrum* (Flörke) Th. Fr. A16 (*46408*).

+*R. disporum* (Naeg.) Müll. Arg. A2 (*46298*), A4 (*46316*), A6 (*46324*), A14 (*46363*), A21 (*46423*), E1 (*46464*), E2 (*46507*), E8 (*46539*).

R. geographicum (L.) DC. A2 (*46299*), A16 (*46398*), E1 (*46478*), E2 (*46483*), E8 (*46532*).

+*R. parvum* Runem. A16 (*46399*). Previously known from Greenland, Ellesmere Island, Richardson Island in Coronation Gulf, and the east coast of

Hudson's Bay.

*+ *R. pusillum* Runem. A21 (*46418*), E1 (*46474*). This is a very interesting tiny species which commences on the thallus of *Sporastatia testudinea.* It is known from the high mountains of southern Europe and has been previously reported from Alaska and the Yukon.

R. superficiale (Schaer.) Vain. A2 (*46291*), A4 (*46311*), A5 (*46323*), A6 (*46325*), A14 (*46356*), A16 (*46384*), A20 (*46413*), A21 (*46422*), A23 (*46443*), E2 (*46483*), E8 (*46531*).

+*Rhizoplaca melanopthalma* (Ram.) Leuck. & Poelt A2 (*46006*), A14 (*46372*), E2 (*46494*), E7 (*46253*).

*+*Rinodina occidentalis* Lynge A21 (*46426*), E1 (*46461*).

+*R. roscida* (Sommerf.) Arn. A2 (*46022*), A4 (*46060*), A5 (*46064*).

+*R. turfacea* (Wahlenb.) Körb. A2 (*46021*), A5 (*46068*), A21 (*46190*), E1 (*46216*).

+*Sarcogyne simplex* (Dav.) Nyl. A4 (*46310*), A11 (*46339*), A14 (*46351*), E1 (*46460*).

*+*Solorina bispora* Nyl. A2 (*46029*), A9 (*46106*), A13 (*46137*), E1 (*46199*).

+*Spilonema revertens* Nyl. A2 (*46036*).

Sporastatia testudinea (Ach.) Mass. A2 (*46292*), A4 (*46309*), A5 (*46320*), A6 (*46332*), A14 (*46354*), A16 (*46383*), A20 (*46310*), A21 (*46320*), A23 (*46435*), E1 (*46449*), E2 (*46489*), E6 (*46515*), E8 (*46528*).

**Squamarina lentigera* (Web.) Poelt E5 (*46252*).

*+*Staurothele arctica* Lynge A11 (*46338*), E2 (*46501*).

+*S. clopima* (Wahlenberg.) Th. Fr. A11 (*46341*), A14 (*46349*).

+*Stereocaulon alpinum* Laur. A9 (*46101*), A13 (*46134*).

+*S. glareosum* (Sav.) Magn. A2 (*46004*), A3 (*46045*), A5 (*46079*), A10 (*46109*), A11 (*46121*), E1 (*46223*), E3 (*46246*).

+*S. groenlandicum* (Dahl) Lamb A16 (*46143*). Contains atranorin and anziaic acid in GE tests.

+*S. rivulorum* Magn. A17 (*46151*), A21 (*46188*).

+*Thamnolia subuliformis* (Ehrh.) W. Culb. A4 (*46052*), A7 (*46092*), A12 (*46125*), A16 (*46146*), A18 (*46169*), A21 (*46181*), E1 (*46235*).

T. vermicularis (Sw.) Ach. A2 (*46015*).

+*Toninia caeruleonigricans* (Lightf.) Th. Fr. A2 (*46005*), A11 (*46116*), E1 (*46215*), E3 (*46248*), E7 (*46258*).

+*T. cumulata* (Sommerf.) Th. Fr. A2 (*46020*).

+*T. tristis* Th. Fr. A1 (*46002*).

+*Trapelia coarctata* (Smith & Sowerby) Choisy A16 (*46389*).

+*Tremolecia atrata* (Ach.) Hertel A4 (*46312*), A5 (*46322*), A16 (*46382*), A20 (*46411*), E2 (*46487*), E8 (*46540*).

+*Umbilicaria cylindrica* (L.) Del. ex Duby A4 (*46303*).

*+*U. havaasii* Llano A5 (*46085*), E1 (*46229*).

+*U. hyperborea* (Ach.) Hoffm. A16 (*46141a*).

+*Verrucaria arctica* Lynge A14 (*46364*), E1 (*46459, 46485*).

**V. margacea* Wahlenb. E1 (*46483*).

+*Xanthoparmelia centrifuga* (L.) Hale A2 (*46019*), A21 (*46178*).

+*X. separata* (Th. Fr.) Hale A9 (*46105*), A17 (*46152*), A21 (*46180*).

+*Xanthoria candelaria* (L.) Th. Fr. A2 (*46301a*), A4 (*46053*), A14 (*46368*), E2 (*46244*).

X. elegans (Link) Th. Fr. A1 (*46284*), A2 (*46301b*), A4 (*46304*), A6 (*46327*), A11 (*46340*), A14 (*46375*), A21 (*46421*), E1 (*46465*), E6 (*46513*).

+*X. elegans* var. *splendens* (Darb.) Christ. ex Poelt A6 (*46088*), E1 (*46211*), E8 (*46267*).

X. sorediata (Vain.) Poelt. A14 (*46347*).

Lichen Parasites

Discothecium gemmiferum Vouax. On *Sporastatia testudinea,* A16 (*46385*).

Rhabdospora lecanorae Bouly de Lesd. On *Lecanora polytropa,* A14 (*46352*).

Tichothecium pygmaeum Körb. On *Lecidea auriculata,* A23 (*46442*).

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Received 7 September 1983
Accepted 16 August 1984

Some Phenological Observations Across Canada's Boreal Regions

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Erskine, Anthony J. 1985. Some phenological observations across Canada's boreal regions. Canadian Field-Naturalist 99(2): 188–195.

Dates of first flowering of plants and spring arrivals of birds were recorded at five locations in boreal Canada in 1971-75. The data were compared to establish the phenological sequence of the years and to correlate this with seasonal temperature (accumulated degree-days above 42° F). Correlations were poor, and of little if any predictive value.

Key words: Phenology, flowering, bird migration, boreal Canada.

The study of phenology attracted widespread interest among naturalists in the past, both for its intrinsic interest and in hopes of gaining new insight and predictive capability regarding the timing of the seasons. Such visible events as the flowering of plants or the arrival of birds have an appeal that is lacking in the cold statistics of the meteorological record. It has been recognized for many years that late flowering or late arrivals are related to lower-than-normal temperatures (and conversely), and climatologists have been able to use phenological records to extend their comparisons back in time beyond the periods covered by systematic weather observations (e.g. Bryson and Murray 1977). Individual naturalists were recording phenological events in the 1700's and even earlier, but organized collection of phenological data was most active in the late 1800's and early 1900's, when networks of observers were spread across several countries including Canada (Stupart 1922; also see Glendenning 1943; Minshall 1947, for brief reviews). Bird migration observers across North America also were organized through the efforts of the United States Biological Survey, and their findings were reported in the publications of W. W. Cooke (1888 et seq.). Canada was a new country then, and most observers were concentrated close to the U.S. border. Few data came from the boreal, subarctic, and arctic regions even after aeroplanes eased travel to remote areas. Air travel called for better meteorological forecasts, which led to an increased network of weather stations. Thus, we are now in a much better position to explore phenological relationships than 50 to 100 years ago. A small resurgence of Canadian interest is evident in phenological papers from northern areas published in this journal in recent decades (Bruggemann and Calder 1953; Moss 1960; Krebs 1964; Weeden 1968; Ryder 1971; Parker 1977; Hoefs 1979).

Many different phenomena have been recorded (see Glendenning 1943). Recent observers have reported mainly first flowering dates of plants, although Ryder (1971) reported bird arrival dates, and Krebs (1964) included bird nesting, mosquito emergence, and ice break-up. Most recent studies in Canada were done peripherally to the main occupations of field-workers, and only relatively conspicuous events are likely to have been recorded at, or soon after, the times they actually occurred. In 1971 to 1975, I recorded flowering dates of plants and arrivals of birds in several areas across the boreal regions of Canada, during my studies of bird populations (Erskine 1977). In view of the scarcity of such information from our boreal regions, I present some of these data, and correlate them with temperature data from the same areas.

Study areas and methods

The areas where observations were made (Figure 1), my arrival and departure dates there, and the weather stations from which data were used, were:

- 1971 — Lac Hébécourt, Québec (48°31′N, 79°23′W), ranging up to 50 km W and 25 km E; 18 May to 6 July; temperature data from Poularies (48°39′N, 78°59′W) 30 km NE.
- 1972 — Birch River, Manitoba (52°23′N, 101°06′W), ranging up to 50 km N and 30 km S; 16 May to 8 July; temperature data from Birch River.
- 1973 — Doré Lake, Saskatchewan (54°40′N, 107°13′W), ranging up to 30 km S; 14 May to 8 July; temperature data from La Ronge (55°05′N, 105°15′W). 100 km NE.
- 1974 — Kledo Creek, British Columbia (58°49′N, 123°32′W), ranging up to 20 km W and 60 km E; 15 May to 7 July; temperature data from Fort Nelson (58°48′N, 122°41′W), 50 km E.
- 1975 — Smithers, British Columbia (54°47′N, 127°10′W), ranging up to 25 km N and 20 km S; 15 May to 8 July; temperature data from Smithers.

I was absent from those areas for brief periods totalling 7 to 10 days each year.

I recorded the dates on which blooms of flowering

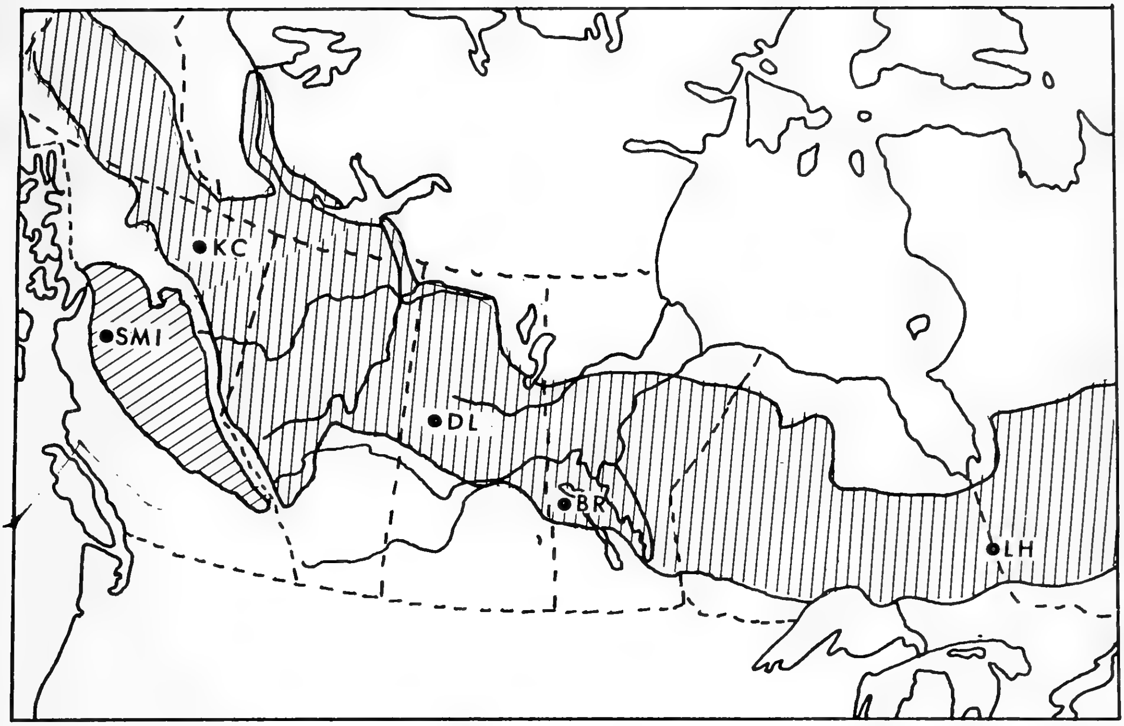

FIGURE 1. Locations of study areas in Canada. SMI = Smithers; KC = Kledo Creek; DL = Doré Lake; BR = Birch River; LH = Lac Hébécourt. Boreal Region shown hatched.

plants were first seen to be fully expanded. Only relatively obvious flowers were noted, and grasses, sedges, and most trees were ignored. No special search for flowering individuals of a species was made, but occasionally the sight of conspicuous leaves of a species led to subsequent detection of bloom earlier than might have occurred by chance.

Birds were recorded when encountered, both in the course of systematic observations on study plots and at other times. First detection was either by song or by sight. No special search, other than that inherent in visiting the appropriate habitats, was made for particular species.

Species of plants which had commenced flowering before my arrival in the study areas, and birds which had arrived earlier, were omitted from the comparisons.

I compared flowering or arrival dates for the various species between pairs of years in order to establish a relative sequence of the years. By comparing separately those plants flowering, on the average, in May, in the first half of June, and after mid-June, and the birds which arrived before or after 26 May, the possible variations in phenology through a season can be examined. Within any of these groups, each pair of years was compared directly, and in comparison with each of the other years in turn, thus giving four estimates of the relative sequence and interval of the pair of years being compared, for example:

72 earlier than 75

— by comparing each with 71	1.88 d
by direct comparison	1.33 d
by comparing each with 73	0.97 d
by comparing each with 74	2.01 d
Mean of above values	1.54 d

Direct comparisons were italicized in each case.

As day length would have changed in the same pattern in all years, the most obvious environmental factor that might influence phenology was temperature. I summed the cumulative degree-days (in °F) above 42°F (the meteorological data were collected in those units) up to various dates for comparison with number of days later than 1972.

Results

a) *Flowering dates*. Each year I recorded first sightings of blooms of 70 to 120 plant species. Some species were seen in only one or two areas; first dates for 64

TABLE 1. Flowering dates of plants in five boreal study areas, 1971–75.

Species	First date blooming at: Lac Hébécourt 1971	Birch River 1972	Doré Lake 1973	Kledo Creek 1974	Smithers 1975
a) Species with late May means					
Petasites palmatus Sweet Coltsfoot	22 May	14 May	13 May	14 May	16 May
Caltha palustris Marsh Marigold	20 May	15 May	19 May	—	—
Calypso bulbosa Fairy Slipper	—	14 May	19 May	25 May	18 May
Fragaria virginiana Wild Strawberry	??	20 May	14 May	22 May	18 May
Viola [*pallens*] *renifolia* Small White Violet*	[22 May]*	15 May	20 May	24 May	21 May
Ribes oxyacanthoides [*setorum*] Prickley Currant	??	—	21 May	25 May	[20 May]
Viola septentrionalis [*adunca*] Blue Violet	20 May	16 May	19 May	[4 June]	[18 May]
Disporum trachycarpum Fairybells	—	26 May	21 May	—	20 May
Chamaedaphne calyculata Leatherleaf	22 May	—	22 May	22 May	—
Arctostaphylos uva-ursi Bearberry	??	19 May	27 May	—	20 May
Corydalis aurea Golden Corydalis	—	—	24 May	3 June	20 May
Ribes glandulosum Skunk Currant	30 May	24 May	28 May	—	—
Amelanchier alnifolia Saskatoon	—	22 May	28 May	5 June	26 May
Viola rugulosa Tall White Violet	??	26 May	31 May	5 June	18 May
Prunus pensylvanica Fire Cherry	4 June	24 May	28 May	—	—
Mertensia paniculata Blue Bells	12 June	26 May	21 May	—	—
Rubus pubescens Dewberry	4 June	24 May	—	3 June	29 May
Viburnum edule [*pauciflorum*] Squashberry	8 June	21 May	30 May	5 June	[28 May]
Andromeda glaucophylla [*polifolia*] Bog Rosemary	7 June	23 May	[29 May]	[3 June]	—
Coptis groenlandica Goldthread	7 June	24 May	30 May	—	—
b) Species with early June means					
Trientalis borealis [*latifolia*] Starflower	12 June	29 May	31 May	—	[4 June]
Sambucus pubens Redberry Elder	7 June	26 May	—	—	14 June
Rubus acaulis Dwarf Raspberry	—	1 June	30 May	17 June	—
Prunus virginiana Choke-cherry	30 May	31 May	13 June	22 June	1 June
Actaea rubra Red Baneberry	8 June	2 June	30 May	5 June	31 May
Cornus canadensis Bunchberry	13 June	2 June	1 June	10 June	14 June
Aralia nudicaulis Wild Sarsaparilla	16 June	31 May	31 May	17 June	8 June
Corallorhiza trifida Early Coralroot	12 June	30 May	29 May	22 June	16 June
Arenaria lateriflora Grove Sandwort	??	1 June	2 June	18 June	15 June
Lathyrus ochroleucus Yellowish Vetchling	—	5 June	13 June	12 June	8 June
Smilacina trifolia Three-leafed False Solomons Seal	18 June	1 June	—	10 June	—
Lathyrus venosus Purple Vetchling	—	5 June	20 June	17 June	31 May
Mitella nuda False Mitrewort	??	3 June	2 June	17 June	22 June
Ledum groenlandicum Labrador Tea	11 June	1 June	8 June	11 June	30 June
Trifolium repens White Clover	18 June	19 June	29 May	24 June	2 June
Ranunculus abortivus Kidneyleaf Buttercup	??	10 June	—	12 June	15 June
Fragaria vesca Woodland Strawberry	8 June	—	31 May	18 June	28 June
Maianthemum canadense False Lily-of-the-Valley	16 June	2 June	13 June	21 June	—
Rosa acicularis Prickly Rose	??	3 June	20 June	12 June	16 June
Cornus stolonifera Red-osier Dogwood	18 June	6 June	16 June	18 June	16 June
Calla palustris Water Arum	??	10 June	8 June	—	26 June
c) Species with late June means					
Trifolium hybridum Alsike Clover	18 June	17 June	10 June	5 June	22 June
Orchis rotundifolia Small Round-leafed Orchis	—	5 June	24 June	29 June	—
Geranium bicknellii Bicknell's Cranesbill	??	??	30 June	12 June	16 June
Pyrola asarifolia Pink Pyrola	??	23 June	—	9 June	27 June
Lonicera dioica Climbing Honeysuckle	—	9 June	23 June	28 June	—
Stellaria longipes Long-stalked Starwort	24 June	5 June	24 June	28 June	—
Achillea millefolium Yarrow	24 June	11 June	24 June	24 June	22 June
Linnaea borealis Twinflower	28 June	9 June	20 June	24 June	25 June
Galium septentrionale Northern Bedstraw	—	10 June	30 June	28 June	23 June

TABLE 1. Flowering dates of plants in five boreal study areas, 1971–75. (Concluded)

Species	First date blooming at: Lac Hébécourt 1971	Birch River 1972	Doré Lake 1973	Kledo Creek 1974	Smithers 1975
Streptopus roseus Rosy Twisted-stalk	16 June	—	—	20 June	2 July
Geum macrophyllum Broad-leafed Avens	16 June	29 June	24 June	27 June	28 June
Potentilla norvegica Norwegian Cinquefoil	??	26 June	24 June	21 June	30 June
Habenaria obtusata Blunt-leafed Orchis	—	4 July	26 June	17 June	22 June
Trifolium pratense Red Clover	18 June	19 June	8 July	??	??
Matricaria matricarioides Pineapple-weed	??	19 June	??	5 July	22 June
Pyrola virens Green Pyrola	??	??	24 June	27 June	25 June
Crysanthemum leucanthemum Oxeye Daisy	24 June	25 June	—	—	27 June
Moneses uniflora One-flowered Pyrola	1 July	18 June	26 June	27 June	2 July
Thalictrum polygamum Tall Meadow-rue	24 June	2 July	—	18 June	5 July
Rubus idaeus Wild Raspberry	28 June	??	20 June	27 June	2 July
Epilobium angustifolium Fireweed	??	23 June	3 July	24 June	6 July
d) Species with early July means					
Melilotus alba White Sweet Clover	??	25 June	6 July	28 June	6 July
Pyrola secunda One-sided Pyrola	—	30 June	4 July	7 July	—

*Where two June taxa are equivalent for the purposes of this analysis the least common use is bracketed and the date of the year that name applies to is also bracketed.

TABLE 2. Spring arrival dates of migrant bird species in five boreal study areas, 1971–75.

Species	Lac Hébécourt 1971	Birch River 1972	Doré Lake 1973	Kledo Creek 1974	Smithers 1975
a) Mean arrival on or before 25 May					
Melospiza lincolnii Lincoln's Sparrow	20 May	—	17 May	15 May	15 May
Seiurus noveboracensis Northern Waterthrush	21 May	17 May	23 May	15 May	15 May
Mniotilta varia Black-and-white Warbler	20 May	17 May	14 May	23 May	—
Vireo solitarius Solitary Vireo	20 May	21 May	21 May	18 May	18 May
Dendroica virens Black-throated Green Warbler	26 May	19 May	16 May	—	—
Seiurus aurocapillus Ovenbird	24 May	16 May	21 May	23 May	—
Empidonax minimus Least Flycatcher	23 May	18 May	21 May	19 May	27 May
Dendroica petechia Yellow Warbler	27 May	26 May	—	15 May	25 May
Setophaga ruticilla American Redstart	20 May	18 May	21 May	6 June	18 May
Pheucticus ludovicianus Rose-breasted Grosbeak	28 May	18 May	21 May	25 May	—
Wilsonia pusilla Wilson's Warbler	27 May	—	27 May	26 May	16 May
Empidonax flaviventris Yellow-bellied Flycatcher	3 June	21 May	20 May	25 May	—
Dendroica fusca Blackburnian Warbler	28 May	21 May	27 May	—	—
b) Mean arrival on or after 26 May					
Chordeiles minor Common Nighthawk	7 June	18 May	23 May	—	—
Tyrannus tyrannus Eastern Kingbird	31 May	23 May	23 May	—	—
Contopus sordidulus Western Wood-Pewee	—	30 May	23 May	5 June	23 May
Catharus ustulatus Swainson's Thrush	20 May	26 May	21 May	3 June	27 May
Vermivora peregrina Tennessee Warbler	28 May	16 May	20 May	2 June	1 June
Contopus borealis Olive-sided Flycatcher	5 June	22 May	23 May	—	28 May
Dendroica pensylvanica Chestnut-sided Warbler	28 May	22 May	1 June	—	—
Geothlypis trichas Common Yellowthroat	23 May	21 May	30 May	5 June	24 May
Dendroica magnolia Magnolia Warbler	24 May	21 May	24 May	6 June	3 June
Vireo philadelphicus Philadelphia Vireo	23 May	27 May	28 May	6 June	—
Dendroica castanea Bay-breasted Warbler	28 May	22 May	24 May	9 June	—
Dendroica striata Blackpoll Warbler	7 June	26 May	—	23 May	1 June
Wilsonia canadensis Canada Warbler	6 June	22 May	28 May	7 June	—
Oporornis philadelphia, Mourning (MacGillivray's) *(O. Tolmiei)* Warbler	31 May	26 May	1 June	5 June	(31 May)
Vireo olivaceus Red-eyed Vireo	1 June	26 May	27 May	6 June	15 June
Empidonax alnorum Alder Flycatcher	2 June	28 May	6 June	8 June	13 June

species observed in three or more areas are given in Table 1. Apparent replacement species were grouped in a few cases.

b) *Migration arrivals*. Similarly I recorded first dates for 31 species of birds detected in three or more study areas (Table 2). A few species seen mainly around colonies (Bank Swallow, *Riparia riparia*, and Cliff Swallow, *Hirundo pyrrhonota*), or for which the dates were believed to be unrepresentative (e.g. Cedar Waxwing, *Bombycilla cedrorum*), were omitted. As most non-passerine birds had arrived before I reached my study areas, arrival dates obtained were mainly for insectivorous species.

c) *Sequence of years*. I obtained mean values for the number of days separating dates of plant flowering in the five years, for three different periods, and of bird arrivals for two different periods (Table 3).

d) *Temperatures*. Temperature data were available only from the late 1960's onward for two of the five stations used, so I selected 1971-1980 as a standard period (Table 4). Tabulation of degree-day accumulations through the various periods used revealed that, among the five years of study, only 1972 averaged warmer than the mean for 1971-1980. The other years were generally cool, with 1974 the coldest of the decade at all stations.

Discussion

If temperatures provide the major control that determines the times of flowering of plants and of arrival of birds, comparisons between areas will be influenced by whether or not the locations are on the same isotherms. We recognize intuitively that no single isotherm will adequately describe the variations in temperature at widely-spaced stations over a period of months, as an isotherm represents an average over a predetermined period; one station might warm up more quickly but to a lower final level than another station with the same overall mean. Nevertheless, we expect that stations the same distance north of the southern edge of the boreal forest will show roughly the same patterns of temperature variation through the seasons, and very generally this is true. I attempted to find study areas at roughly the same "ecological latitude", but scarcity of access roads and of the desired variety of forest stands led to some departures from the planned placement. The Birch River area studied in 1972 was 100–200 km south of the preferred

TABLE 3. Comparisons of mean dates of flowering or arrival between years, with data sets grouped as in text.

Years compared[1]	No. days different between years[2]	(mean)
(a) Plants flowering in May		
72 vs. 75	1.88, *1.33*, 0.97, 2.01	(1.54)
75 vs. 73	0.75, 1.79, *2.15*, 1.92	(1.65)
73 vs. 74	3.92, 6.98, *6.17*, 5.94	(5.75)
74 vs. 71	*4.00*, 0.45, 1.75, 0.58	(1.59)
(b) Plants flowering in first half of June		
72 vs. 73	2.61, *3.18*, 3.76, 1.14	(2.67)
73 vs. 71	*7.64*, 7.07, 4.79, 7.41	(6.73)
71 vs. 75	*1.00*, -0.70, 0.77, 2.95	(1.01)
75 vs. 74	3.33, 3.33, 0.71, *1.38*	(2.19)
(c) Plants flowering in second half of June and early July		
72 vs. 71	*4.20*, 8.66, 4.67, 0.66	(4.44)
71 vs. 74	*0.33*, 0.80, -1.05, 0.08	(0.04)
74 vs. 73	-0.45, 3.54, *0.93*, 3.36	(1.85)
73 vs. 75	5.23, -2.77, *1.83*, 4.26	(2.14)
(d) Birds arriving up to 25 May		
72 vs. 73	1.55, *1.62*, 0.00, 5.34	(2.13)
73 vs. 75	2.92, 1.05, *-2.67*, 1.97	(0.82)
75 vs. 74	0.50, 2.05, 7.39, *2.75*	(3.17)
74 vs. 71	*1.25*, 1.50, 0.05, 1.00	(0.95)
(e) Birds arriving after 25 May		
72 vs. 73	4.07, *3.00*, -0.83, -1.12	(1.28)
73 vs. 71	*3.00*, 4.07, 3.46, 1.54	(3.02)
71 vs. 75	*4.08*, 2.57, 2.62, 3.68	(3.24)
75 vs. 74	2.37, 4.58, 4.29, *2.77*	(3.50)

[1]Arranged in order of mean differences; figures indicate that the mean flowering date (for plants flowering in May) was 1.88 d later in 1975 than in 1972, and so on;

[2]The four figures shown were obtained as follows:

72 earlier than 75 —	by comparing each with 71	1.88 d
	by direct comparison	1.33 d
	by comparing each with 73	0.97 d
	by comparing each with 74	2.01 d
	Mean of above values	1.54 d.

Direct comparisons italicized in each case.

TABLE 4. Accumulated degree-days (above 42°F) and mean values for selected weather stations over different periods in spring (from Monthly Record of Meteorological Observations in Canada, Environment Canada, 1971-1980).

Weather station and year of study	Accumulated degree-days (°F) in year of study/mean 1971-80			
	through 15 May	through 25 May	through 31 May	through 15 June
Poularies, Quebec, 1971	61/94	111/211	172/291	368/483
Birch River, Manitoba, 1972	176/169	343/290	430/381	709/604
LaRonge, Saskatchewan, 1973	40/122	129/208	238/279	370/481
Ft. Nelson, British Columbia, 1974	63/150	152/238	169/305	383/519
Smithers, British Columbia, 1975	100/119	126/173	182/223	308/383

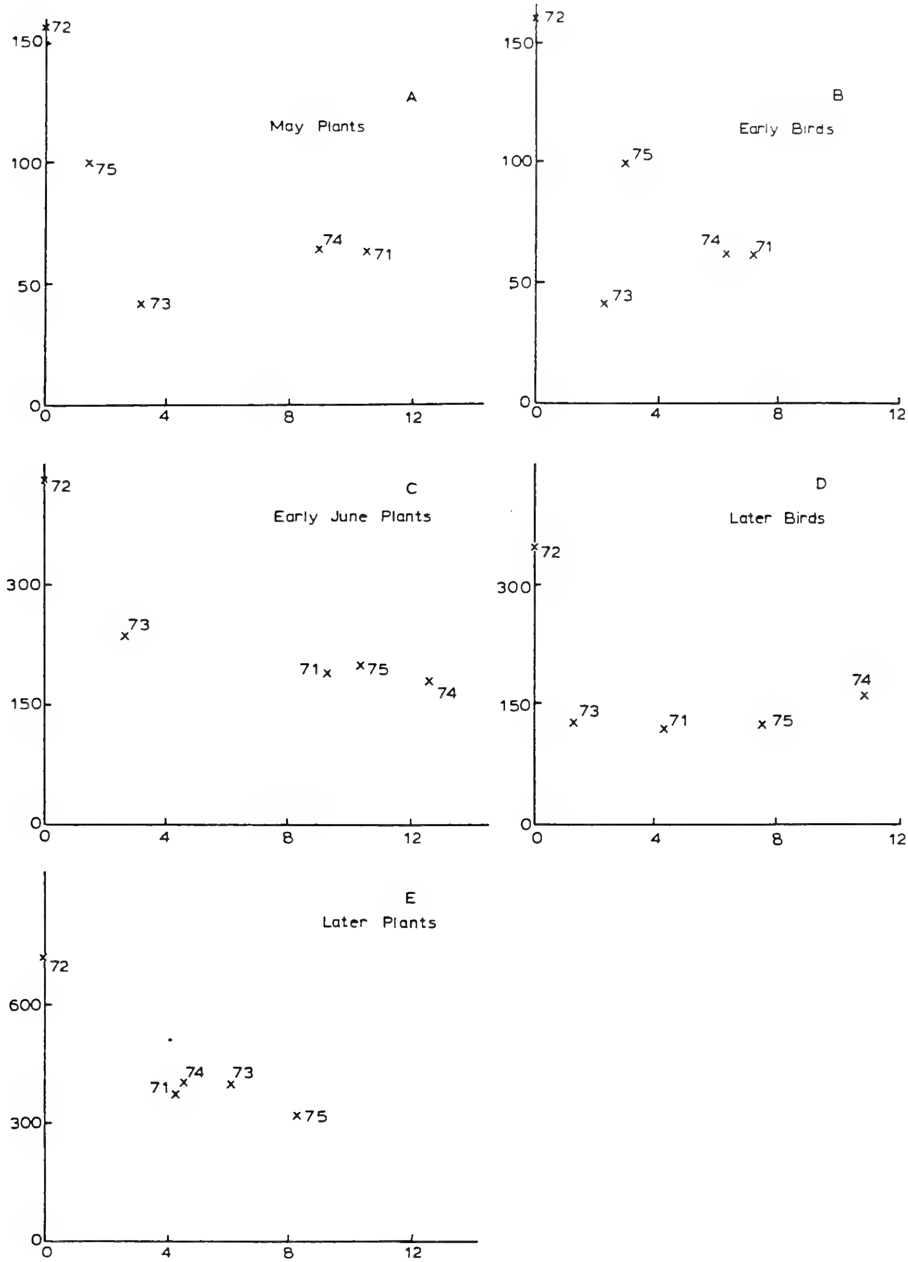

FIGURE 2. Comparisons of phenology with temperature in five study areas, 1971–75. Phenology (horizontal axis) is expressed as the mean number of days later than in 1972 that the event occurred in a given year. Temperature (vertical axis) is expressed in accumulated degree-days (° F) above 42° F for the following periods: A. and B. through 15 May; C. through 31 May; D. through 25 May; E. through 15 June.

latitude, and the presence there of some plants and birds of more southern distribution made this apparent later. Conversely, the Kledo Creek area (1974) was 100–200 km north of that originally selected in that region, but I did not detect obvious differences in plants or birds there. One could anticipate that the flowering and arrival dates in 1972 would have averaged earlier than in the other years, as the observations that year were made in a less boreal area, and this was the case, for all periods, and for both plants and birds. However, the dates for 1974 were not consistently later than in other years, despite the more northern situation; presumably other factors than "ecological latitude" also influenced their timing.

The comparisons of timing (Table 3) differed for different periods. The plants which flowered during late May and the birds which arrived 15–25 May presumably were responding to environmental conditions, including temperature, that prevailed prior to mid-May. In that early period, dates in 1973 and 1975 followed quite closely after 1972, whereas 1974 and 1971 were much later, both for plants and birds. The later arriving birds (26 May–5 June) and the plants that flowered in the first half of June responded to environmental conditions of a later period, and those two data sets similarly agreed in the sequence of years indicated: 1973 followed 1972, with 1971, 1975, and 1974 later. Only plant flowering dates were available for late June and early July, when the sequence of years had changed again, with 1971 and 1974 together much later than 1972, and 1973 and 1975 still farther behind

For correlations with flowering dates, local temperature data would be appropriate. For birds, however, migration presumably would have been triggered by conditions some distance to the south; use of local temperature data might be expected to give less good correlations than for plants, but I used the same weather stations for both comparisons. Many other uncertainties enter into the observational data, and I made no attempt to standardize site characteristics such as exposure or soils which might affect flowering dates. With only one year's data from each area, there was no possibility of averaging out uncertainties. My comparisons were restricted to the relative sequence of the years against the accumulated sum of degree-days above 42° F (Figure 2). The results shown involved summing degree-days up to the start of the period being considered, although other combinations were tried and rejected as less satisfactory.

The apparent "straight-line relationship" between the data points, excepting 1972 in all cases and 1973 for the two early data sets, may have no real significance, as the slopes vary from 0 or even faintly positive to markedly negative; presumably data that were precisely standardized would give a zero slope, and the departures from this as well as from the straight line reflect inadequate standardization. The aberrant position of 1972, in which the recorded events all apparently occurred at higher degree-day sums than in other years, may reflect its more temperate location. For such a place, summing of degree-days over the entire period may be inappropriate, as brief periods above the threshold for growth (42° F) may occur early and be succeeded by killing frosts there, whereas farther north the growth threshold might not be exceeded in early warm spells. Moss (1960) computed "heat-sums" only over 5–10 day periods prior to peak flowering dates for a particular species; however, first flowering dates may involve individual plants that are in situations where they can benefit even from early warm spells. The low degree-day totals for events in the early period in 1973 may reflect that the weather station used (LaRonge) is farther north and adjacent to a large lake, around which temperatures warm up less rapidly in spring than farther inland. As a check on whether the degree-days in only the later part of the period were influencing phenology, I also compared degree-days accumulated starting from 1 May, but no obviously better fit resulted than with the complete period.

Phenological dates reflect a natural integration of the effects of various environmental factors into a single index. Ecology is full of attempts to represent multi-factor systems by single, numerical indices, but we still have not yet determined which factors have been integrated into each type of phenological observation. Therein lies the challenge of phenology.

Acknowledgments

H. Harries, H. Boyd, and P. Hicklin commented helpfully on earlier drafts of this manuscript.

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Received 10 May 1983
Accepted 17 September 1984

Habitat Use by Non-hibernating Small Mammals of the Kananaskis Valley, Alberta

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Millar, John S., Duncan G. L. Innes, and Valerie A. Loewen. 1985. Habitat use by non-hibernating small mammals of the Kananaskis Valley, Alberta. Canadian Field-Naturalist 99(2): 196–204.

A survey of small mammals of the Kananaskis Valley, Alberta, was conducted in 1980, 1981 and 1982. The use of 14 macrohabitats by five species was studied in detail. The Deer Mouse, *Peromyscus maniculatus*, was the most abundant species (43% of all captures), followed by the Red-backed Vole, *Clethrionomys gapperi* (32%), the Long-tailed Vole, *Microtus longicaudus* (12%), the Heather Vole, *Phenacomys intermedius* (9%), and the Meadow Vole, *Microtus pennsylvanicus* (4%). These general levels of abundance reflected both niche width and abundance within major habitats. All five species showed some macrohabitat segregation, although *Microtus longicaudus* and *Phenacomys intermedius* showed high niche overlap and low microhabitat segregation.

Key Words: habitat, niche overlap, *Peromyscus, Microtus, Phenacomys, Clethrionomys.*

The small mammal fauna of the Kananaskis Valley (51°N; 115°W) and surrounding Front Ranges of the Rocky Mountains is diverse, consisting of three species of shrews, four bats, nine cricetid rodents and at least seven sciurid rodents (Salt and Clarke 1979; Mill and Anderson 1980). Several species have been studied in some detail. For example, the demography and seasonal phenology of chipmunks, *Eutamias amoenus* and *E. minimus* (Sheppard 1968, 1969, 1971, 1972), Columbian Ground Squirrels, *Spermophilus columbianus* (Boag and Murie 1981; Murrie and Harris 1982), Pikas, *Ochotona princeps* (Millar 1972; Millar and Zwickel 1972; Sharp 1973), Richardson's Voles, *Microtus richardsoni* (Ludwig 1981), Heather Voles, *Phenacomys intermedius* (Innes and Millar 1982) and Deer Mice, *Peromyscus maniculatus* (Millar and Innes 1983) have been documented. Habitat affinities are known for only some of these species. Least Chipmunks and Pikas are found only in or near talus (Meredith 1976; Tapper 1973; respectively) and Richardson's Voles are restricted to high-elevation meadows adjacent to running water (Ludwig 1981). The habitat relationships of most species, with the exception of small mammals in low-elevation forests (Morris 1980), are known only from annotated checklists (Wallis and Wershler 1972; Salt and Clarke 1979; Mill and Anderson 1980).

During recent studies on small mammals within the Kananaskis Valley, data on species composition and macrohabitats were obtained. Here these data are used to evaluate the habitat relationships among five non-hibernating small mammals.

Methods

Survey trapping was conducted within the Kananaskis River drainage system, between the Kananaskis Park boundary and Lusk Creek, during 1980, 1981 and 1982 (Figure 1). Sampling involved lines of single Museum Special traps (approximately 15 m spacing), baited with peanut butter and rolled oats. Each line was checked daily and removed after three nights (the fourth day). A total of 102 trap lines and 8900 trap sites (26 700 trap nights) were monitored during the summer months (approximately May through early September). An attempt was made to sample all habitats throughout the summer, although trapping usually began earlier at low-elevation sites than at high-elevation sites.

Habitat was classified around each trapping site, based on the characteristics of the dominant vegetation. The vegetation of the valley consists of a series of zones related to the altitudinal gradient of environmental conditions. Two major vegetation zones are present: Subalpine (1500-2100 m) and Alpine (above 2100 m) (Ogilvie 1969). The Subalpine zone is forested with White Spruce (*Picea glauca*), and Engelmann Spruce (*P. engelmannii*) (and hybrids of the two), as well as Lodgepole Pine (*Pinus contorta*), Subalpine Fir (*Abies lasiocarpa*), Alpine Larch (*Larix lyallii*), and Whitebark Pine (*P. albicaulis*) (Rowe 1972). Young post-fire subalpine forests, particularly at low elevations are dominated by Lodgepole Pine or Trembling Aspen (*Populus tremuloides*). Mature forests are dominated by spruce with fir and larch increasing in importance at higher elevations. The upper Subalpine zone is a transitional region to the Alpine zone. This transitional timberline zone is characterized by a decrease in tree cover and height of trees. Engelmann Spruce, Subalpine Fir, Alpine Larch, and Whitebark Pine are the dominant tree species. Plant communities of the Alpine zone generally exist in response to conditions of snow depth,

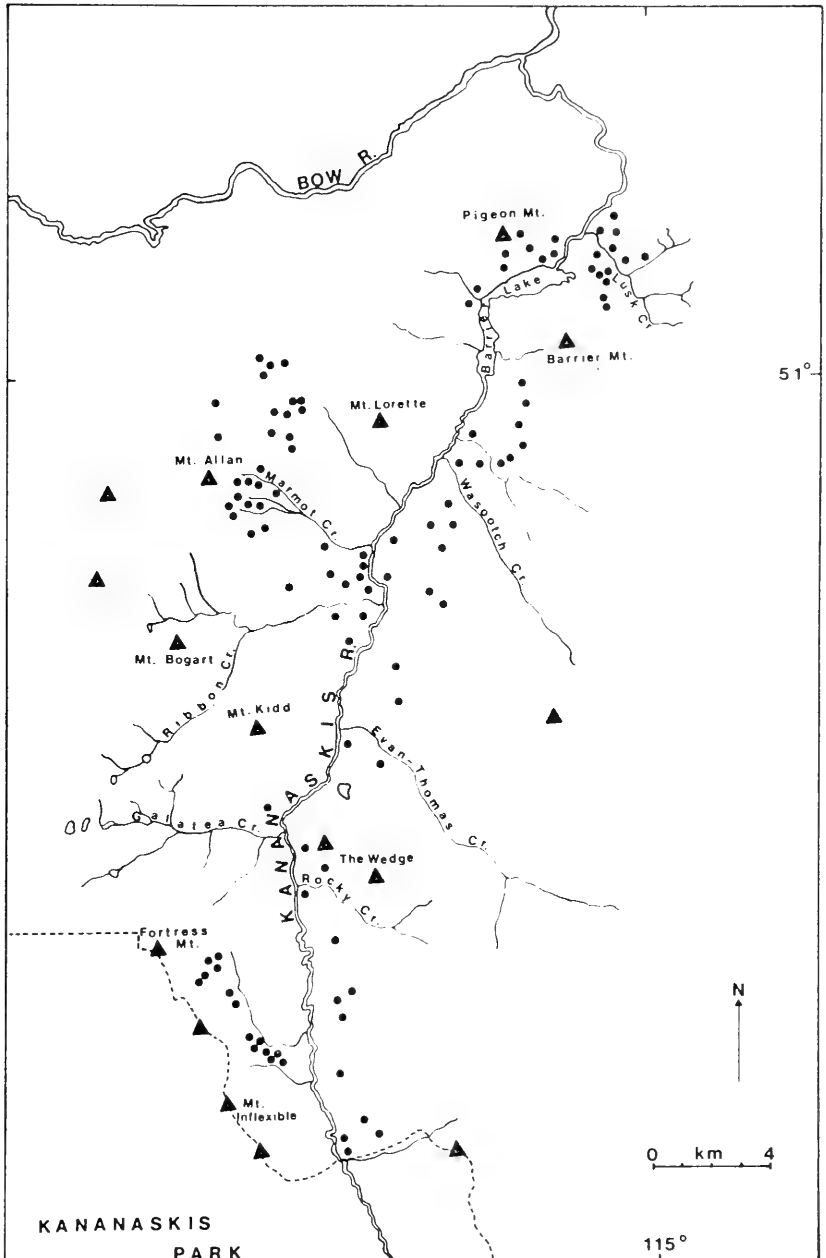

FIGURE 1. Map of the study area. Closed circles represent trapping sites.

TABLE 1. Small mammal habitats sampled in the Kananaskis Valley.

HABITAT TYPE	DESCRIPTION
1. Riparian — coniferous	Stream or river edges within coniferous forests. Usually moist or wet sites with variable vegetation. *Picea* is the most common tree, although *Abies* and deciduous species also occur. Water edges often dominated by cover of shrubs (*Salix, Alnus, Betula*). *Equisetum* and mosses dominate the understory although a variety of herbs occur in open canopy situations. This category also includes conifer dominated seepage areas and areas with impeded drainage where *Ledum groenlandicum*, mosses and sedges are characteristic.
2. Riparian — deciduous	Stream or river edges dominated by deciduous vegetation. Generally includes floodplains and gravel bars. Dominant trees are *Populus balsamifera*, and *P. tremuloides*. Dense cover of shrubs, particularly *Salix*, but also *Potentilla, Betula, Elaeagnus*, and *Shepherdia* may occur. *Dryas drummondii*, grasses, *Smilacina, Castilleja, Epilobium, Parnassia, Zygadenus*, and *Oxyria* are common.
3. Aspen — closed canopy	Usually moist sites, dominated by *Populus tremuloides*, but *Pinus contorta* and *Picea* may occur. Shrub stratum dominated by aspen suckers. Sparse understory of grasses, *Epilobium, Heracleum, Mertensia.*
4. Aspen — open canopy	Usually drier sites with *Populus tremuloides* dominant. Understory is shrub dominated (*Rosa, Symphoricarpos, Prunus, Potentilla, Shepherdia, Juniperus*). Herb layer is grass dominated with a variety of forbs.
5. Pine — closed canopy	Common post-fire habitat of low and intermediate elevations. *Pinus contorta* dominant and may be very dense. Understory sparse and dominated by moss, lichen, and grass. *Erigeron, Aster, Pyrola* and *Arnica* are occasional.
6. Pine — open canopy	Generally well-drained sites of mature *Pinus contorta. Picea* and *Populus tremuloides* may co-occur. Moderately open understory of *Shepherdia, Juniperus, Arctostaphylos, Linnaea, Vaccinium, Elymus* and *Calamagrostis.*
7. Spruce-Subalpine Fir — open canopy	*Picea engelmanni* (hybrid) and *Abies lasiocarpa* dominant. Well-developed shrub layer of *Menziesia, Rhododendron*, and *Vaccinium*. The understory of south-facing aspects contains grasses (*Calamagrostis, Elymus*) and a variety of forbs (*Aster, Castilleja, Arnica*). Northfacing aspects are dominated by mosses and liverworts, but *Phyllodoce, Pedicularis, Valeriana* and *Erigeron* are common.
8. Spruce-Subalpine Fir — closed canopy	*Picea engelmanni* (hybrid) and *Abies lasiocarpa* dominant. Some *Menziesia* and *Alnus* may occur but understory sparse and dominated by mosses. Common forbs include *Linnaea, Cornus* and *Pyrola.*
9. Spruce — open canopy	Dry sites of south and east facing aspects at low to mid-elevations. *Picea* dominant but *Pinus contorta, Pseudotsuga menziesii* and *Populus tremuloides* commonly co-occur. *Shepherdia, Salix, Betula, Juniperus* and *Arctostaphylos* form a well-developed shrub layer. Grass dominates the herb stratum.
10. Clearcuts, avalanche slopes, mixed scrub	Regenerating conifers (*Picea, Abies, Pinus*) are common, but sites are shrub-dominated (*Salix, Betula, Ribes, Shepherdia, Potentilla*). A variety of forbs and grasses occur.
11. Alpine Larch-Subalpine	*Larix lyallii* in association with *Abies lasiocarpa* dominant, however *Picea engelmannii, Pinus albicaulis* and *P. flexilis* may occur. Several shrubs (*Menziesia, Rhododendron, Vaccinium* spp., particularly *V. scoparium*) may be present, as well as a variety of herbs. At timberline, *L. lyallii, A. lasiocarpa*, and *P. engelmannii* stands form complex mosaics with alpine plant associations.

TABLE 1. Small mammal habitats sampled in the Kananaskis Valley *(concluded).*

HABITAT TYPE	DESCRIPTION
12. Subalpine Meadow	Characterized by well-developed soil profiles and complete plant cover of grasses (*Bromus, Elymus, Agropyron, Poa*), sedges, and a wide diversity of forbs. Includes most subalpine meadows and some moist, protected alpine sites, as well as some disturbed sites such as transmission lines and roadsides.
13. Alpine meadow	Characterized by shallow, often rocky, regosolic soils and incomplete plant cover. Occur on wind-exposed sites and protected sites with very thick snow accumulations. A complex variety of plant communities occurs, but major components include *Dryas, Salix* spp., *Kobresia, Oxytropis*, and lichens.
14. Talus and cliffs	Major feature of this category is the dominance of rock over plant cover. Includes rockfields, talus slopes, and cliffs.

wind-exposure, and moisture so that plant associations tend to occur in complex mosaics (Ogilvie 1969).

In addition to the two major vegetation zones, scattered stands exemplifying the Montane zone occur in the valley. These consist of dry sites dominated by open stands of spruce, Lodgepole Pine, and Douglas Fir (*Pseudotsuga menziesii*).

For this study, habitats were broadly classified into 14 major types that reflect the major vegetation zones as well as particular environmental conditions. Thus a designated habitat usually included several plant communities or associations. The habitat categories are presented in Table 1.

Trapping data were tabulated by species as number captured per 100 trap nights, among habitats and years. These data were used to calculate standardized niche breadth of each species and niche overlap between species. These calculations followed Krebs and Wingate (1976) in order to make our results comparable to their study of small mammals at Kluane, Yukon Territory.

Mammalian species reported here were identified from descriptions given by Hall and Kelson (1959) and Soper (1964); nomenclature follows Honacki et al. (1982).

Results

Twenty-five species of small mammals were recorded in the Kananaskis Valley by this survey (Table 2). Some species were relatively rare or had localized distributions. For example, Hoary Marmots and Richardson's Voles were recorded only in or near Marmot Basin (Mt. Allan), Northern Pocket Gophers were recorded only in the lower Kananaskis Valley near Barrier Lake, and only one Bog Lemming was captured (in mature subalpine forest). Golden-mantled Ground Squirrels were captured only occasionally in subalpine and alpine areas. The three shrew species appeared widely distributed, but were captured sporadically, in part because they were too small

TABLE 2. Species of small mammals recorded in the Kananaskis Valley.

Order Insectivora
Family Soricidae
Sorex cinereus, Masked Shrew
Sorex obscurus, Dusky Shrew
Sorex palustris, Water Shrew
Order Rodentia
Family Sciuridae
Eutamias amoenus, Yellow Pine Chipmunk
Eutamias minimus, Least Chipmunk
Spermophilus lateralis, Golden-mantled Ground Squirrel
Spermophilus columbianus, Columbian Ground Squirrel
Tamiasciurus hudsonicus, Red Squirrel
Glaucomys sabrinus, Northern Flying Squirrel
Marmota caligata, Hoary Marmot
Family Cricetidae
Microtus pennsylvanicus, Meadow Vole
Microtus longicaudus, Long-tailed Vole
Microtus richardsoni, Richardson's Vole
Phenacomys intermedius, Heather Vole
Peromyscus maniculatus, Deer Mouse
Clethrionomys gapperi, Red-backed Vole
Synaptomys borealis, Northern Bog Lemming
Ondatra zibethicus, Muskrat
Neotoma cinerea, Woodrat
Family Zapodidae
Zapus princeps, Western Jumping Mouse
Family Castoridae
Castor canadensis, Beaver
Family Erethizontidae
Erethizon dorsatum, Porcupine
Family Geomyidae
Thomomys talpoides, Northern Pocket Gopher
Order Lagomorpha
Family Leporidae
Lepus americanus, Snowshoe Hare
Family Ochotonidae
Ochotona princeps, Pika

to be sampled effectively by Museum Special traps. Alternatively, several species (Columbian Ground Squirrels, Red Squirrels, Northern Flying Squirrels, Woodrats, Pikas, and all larger mammals) were too large to be sampled effectively by Museum Special traps. Among the species that could be effectively sampled by snap-trapping, the chipmunks and Western Jumping Mice had not emerged from hibernation when trapping started each year so that their apparent absence from some low-elevation areas may have been due to their seasonal phenology rather than habitat association. Areas known to contain Richardson's Voles were not sampled.

For these reasons, our consideration of habitat associations was restricted to five non-hibernating species (*C. gapperi, M. pennsylvanicus, P. intermedius, P. maniculatus* and *M. longicaudus*). All five of these species were widely distributed with regard to elevation.

The results of this trapping survey are presented in Table 3. *Peromyscus maniculatus* was the most frequently captured rodent (43% of all captures). *Peromyscus maniculatus* was most abundant (6.3 per 100 trap nights) in talus and rockfields (Habitat 14) over the three years, but were relatively abundant (> 5 per 100 trap nights) in dry aspen (Habitat 4) in 1981 and in rocky alpine meadows (Habitat 13) in 1982. Larch forests (Habitat 11) appeared to be the poorest habitat for *P. maniculatus*; all other habitats yielded more than one *P. maniculatus* per 100 trap nights.

Clethrionomys gapperi was also a frequently captured rodent, comprising 32% of all captures. *Clethrionomys gapperi* was most abundant (6.6 per 100 trap nights) in open spruce-Subalpine Fir forest (Habitat 9) over the three years of the survey, but were also abundant (> 5 per 100 trap nights) in larch-Subalpine Fir forest (Habitat 11) and closed spruce-Subalpine Fir forest (Habitat 8) in 1980 and in coniferous riparian areas (Habitat 1) in 1982. No *C. gapperi* were captured in talus and rock fields (Habitat 14) and very few (< 0.5 per 100 trap nights) were captured in shrub dominated regeneration sites (Habitat 10) or rocky alpine meadows (Habitat 13) over the three years of the study. *Clethrionomys gapperi* was considerably less abundant in 1981 (total abundance of 0.4 per 100 trap nights) than in 1980 or 1982 (total abundance of 2.8 and 2.1 per 100 trap nights, respectively).

Microtus longicaudus was less frequently captured than *P. maniculatus* or *C. gapperi*, and made up 12% of all captures. *Microtus longicaudus* was most abundant in subalphine meadows (Habitat 12; 1.4 per 100 trap nights) and deciduous riparian areas (Habitat 2; 1.2 per 100 trap nights) over the three years of the survey. They were also relatively abundant in rocky alpine areas (Habitat 13; 2.0 per 100 trap nights) in 1980. *Microtus longicaudus* was trapped in all habitats except closed spruce-Subalpine Fir forests (Habitat 8) and were of approximately equal abundance during the three years of the survey.

Phenacomys intermedius was captured with a frequency similar to that of *M. longicaudus*, and comprised 9% of all captures. *Phenacomys intermedius* was most abundant in coniferous riparian areas (Habitat 1; 1.2 per 100 trap nights) over the three years, but was temporarily abundant in open spruce forest (Habitat 9; 1.6 per 100 trap nights) in 1980 and subalpine meadows (Habitat 12; 1.8 per 100 trap nights) in 1982. No *P. intermedius* were captured in closed pine forests (Habitat 5) or closed spruce-Subalpine Fir forests (Habitat 8) over the three years of the study, although they were infrequently captured in all other habitats.

Microtus pennsylvanicus was captured with the least frequency (4% of all captures). No *M. pennsylvanicus* were caught in open aspen areas (Habitat 4), closed pine forests (Habitat 5), closed spruce-Subalpine Fir forests (Habitat 8), larch-subalpine Fir Forests (Habitat 11) or talus and rockfields (Habitat 14). *Microtus pennsylvanicus* were most abundant in subalpine meadows (Habitat 12; 0.8 per 100 trap nights) over the three years of the survey and temporarily abundant in closed aspen forest (habitat 3; 1.4 per 100 trap nights) in 1980. *Microtus pennsylvanicus* was similar to *C. gapperi* in showing reduced abundance in 1981.

In general, the five species showed different habitat affinities. There was, however, a great deal of temporal and spatial variation in habitat associations and most species were recorded in most habitats. This tendency for species to occupy diverse habitats was reflected in estimates of niche breadth. Standardized niche breadths (Table 4) indicated that *M. pennsylvanicus* had the lowest niche breadth in 1981 and 1982 and among all years combined. *Peromyscus manicu-*

TABLE 4. Standardized niche breadths for small mammals in the Kananaskis Valley 1980-82. Macrohabitats with less than 50 trap nights were excluded.

	Standardized Niche Breadths			
Species	1980	1981	1982	Combined Years
Clethrionomys gapperi	0.32	0.42	0.53	0.53
Microtus pennsylvanicus	0.33	0.15	0.21	0.37
Phenacomys intermedius	0.52	0.28	0.55	0.64
Peromyscus maniculatus	0.39	0.74	0.73	0.77
Microtus longicaudus	0.45	0.33	0.52	0.60
Number of Habitats	12	12	14	14

TABLE 3. Mice caught per 100 trap nights 1980–1982. Habitats described in Table 1. Blanks represent < 50 trap nights.

		Habitat Type															
		Riparian		Aspen		Pine		Spruce	Spruce-fir		Shrub	Larch	Meadow		Talus		
Species	Year	conif. 1	decid. 2	closed 3	open 4	closed 5	open 6	open 7	closed 8	open 9	10	11	sub-alpine 12	alpine 13	14	N	Total
Clethrionomys gapperi	1980	1.88	0.0	0.35	—	—	3.51	0.79	9.52	11.11	0.0	15.32	0.0	0.0	0.0	143	2.85
	1981	—	0.0	—	0.53	1.36	0.0	0.57	0.28	1.96	0.40	0.65	0.09	0.05	0.0	36	0.44
	1982	7.14	2.08	0.99	2.04	1.12	2.53	0.99	2.78	9.31	0.59	3.70	2.92	0.76	0.0	279	2.07
	Total	2.58	0.70	0.64	1.17	1.19	2.49	0.87	2.72	6.63	0.46	3.37	1.39	0.45	0.0	458	1.72
Microtus pennsylvanicus	1980	0.43	0.48	1.39	—	—	0.36	0.0	0.0	0.0	0.0	0.0	1.15	0.0	0.0	29	0.58
	1981	—	0.0	—	0.0	0.0	0.0	0.19	0.0	0.0	0.0	0.0	0.09	0.0	0.0	2	0.02
	1982	0.0	0.52	0.0	0.0	0.0	0.0	0.11	0.0	0.18	0.19	0.0	1.11	0.03	0.0	25	0.18
	Total	0.35	0.35	0.67	0.0	0.0	0.06	0.13	0.0	0.07	0.10	0.0	0.82	0.20	0.0	56	0.21
Phenacomys intermedius	1980	1.44	1.42	0.46	—	—	0.48	0.0	0.0	1.59	0.0	1.07	0.57	0.34	0.0	35	0.70
	1981	—	0.0	—	0.0	0.0	0.0	0.0	0.0	0.53	0.13	0.36	0.0	0.50	0.0	20	0.24
	1982	0.0	1.04	0.50	0.68	0.0	0.22	0.44	0.0	0.36	0.59	0.61	1.81	0.36	0.26	72	0.53
	Total	1.17	0.87	0.47	0.29	0.0	0.25	0.27	0.0	0.66	0.36	0.51	0.98	0.41	0.13	127	0.48
Peromyscus maniculatus	1980	1.73	0.42	2.08	—	—	0.24	0.0	3.97	0.0	1.69	0.54	1.39	2.38	10.48	65	1.30
	1981	—	3.51	—	5.29	1.70	1.72	0.09	3.36	2.85	1.06	0.36	0.09	0.65	5.20	91	1.11
	1982	1.59	4.68	1.74	4.08	2.24	2.03	3.94	0.0	1.61	4.20	0.0	3.80	5.79	3.64	456	3.38
	Total	1.76	3.14	1.86	4.67	2.12	1.70	2.48	2.31	1.82	2.76	0.34	2.13	3.66	6.29	612	2.29
Microtus longicaudus	1980	0.14	2.34	0.0	—	—	0.0	0.0	0.0	1.59	1.69	0.81	0.69	2.04	0.0	28	0.56
	1981	—	0.0	—	0.0	0.0	0.0	0.0	0.0	0.53	0.26	0.65	0.64	1.34	0.0	50	0.61
	1982	1.58	1.04	0.12	1.36	0.22	0.06	0.77	0.0	0.54	1.07	0.0	2.28	0.56	0.26	88	0.65
	Total	0.35	1.22	0.06	0.58	0.13	0.04	0.47	0.0	0.73	0.82	0.59	1.42	0.90	1.13	166	0.62
Trap Nights	1980	690	210	864	6	12	825	51	126	252	177	372	864	294	267	5010	
	1981	36	171	48	189	294	405	525	357	561	753	1677	1089	2007	96	8208	
	1982	126	192	804	147	447	3585	912	252	558	1023	324	1707	3021	384	13482	
	Total	852	573	1716	342	753	4815	1488	735	1371	1953	2373	3660	5322	747	26700	

latus had the greatest niche breadth in 1981 and 1982 and among all years combined. The other three species showed intermediate niche breadths. In all species, niche breadths varied considerably among years.

The tendency of these five species to occupy diverse habitats was also reflected in estimates of niche overlap. The greatest niche overlap involved *Phenacomys intermedius* (Table 5), and was greatest between *P. intermedius* and *C. gapperi* in 1980, *P. intermedius* and *M. longicaudus* in 1981 and *P. intermedius* and *M. pennsylvanicus* in 1982. The greatest niche overlap among all years combined was between *P. intermedius* and *M. longicaudus*. The least niche overlap was between *M. pennsylvanicus* and *C. gapperi* in 1980 and 1982 and among all years combined. The complete absence of overlap between *M. pennsylvanicus* and two other species in 1981 was likely related to the low abundance of *M. pennsylvanicus* in that year (Table 3).

These data indicate the tendency for small mammals to occupy similar macrohabitats, but do not indicate the tendency for species to use similar microhabitats within specific areas. The tendency for species to associate at specific sites could be examined because each trap site was operated for three consecutive nights. Multiple captures at individual trapping sites provided some insight into the use of those specific sites by different species. A total of 223 trap sites caught small mammals on consecutive nights (e.g. night 1 and 2 or night 2 and 3). A comparison of the number of second captures of each species and the expected numbers based on overall relative abundances over the three years (Table 6) indicated that second captures involved members of the same species much more often than expected from a random association. Associations with other species were generally less than expected, although the degree of separation between species varied considerably. For example, *C. gapperi* and *P. maniculatus*, *C. gapperi* and *M. longicaudus*, and *P. maniculatus* and *M. longicaudus* were captured at the same site much less frequently than expected ($\chi^2 = 46.7$, 15.6 and 11.4, respectively; $P < 0.001$). *Clethrionomys gapperi* and *M. pennsyl-*

TABLE 5. Niche overlap among small mammals of the Kananaskis Valley 1980-1982.

		C. gapperi	*M. pennsylvanicus*	*P. intermedius*	*P. maniculatus*
M. pennsylvanicus	1980	0.07			
	1981	0.22			
	1982	0.37			
	Total	0.35			
P. intermedius	1980	0.93	0.49		
	1981	0.61	0.0		
	1982	0.49	0.87		
	Total	0.65	0.81		
P. maniculatus	1980	0.20	0.25	0.19	
	1981	0.48	0.0	0.27	
	1982	0.45	0.54	0.76	
	Total	0.48	0.47	0.63	
M. longicaudus	1980	0.31	0.26	0.68	0.25
	1981	0.35	0.16	0.84	0.16
	1982	0.60	0.75	0.83	0.80
	Total	0.56	0.70	0.86	0.68

TABLE 6. Multiple captures of small mammals at individual trap sites. Numbers represent the number of individuals of each species captured on a subsequent night, given the species caught the first night. Numbers in parentheses represent the expected number for each species, based on average abundance of each species and assuming random association.

	Second Capture				
First Capture	*C. gapperi*	*M. pennsylvanicus*	*P. intermedius*	*P. maniculatus*	*M. longicaudus*
C. gapperi	70	1	5	3	1
	(25.8)	(3.1)	(7.2)	(34.5)	(9.4)
M. pennsylvanicus	0	7	0	1	1
	(2.9)	(0.3)	(0.8)	(3.9)	(1.0)
P. intermedius	4	1	3	4	3
	(4.8)	(0.6)	(1.3)	(6.5)	(1.7)
P. maniculatus	7	1	3	80	3
	(30.4)	(3.7)	(8.5)	(40.5)	(11.0)
M. longicaudus	0	0	1	3	21
	(8.0)	(1.0)	(2.2)	(10.8)	(2.9)

vanicus, *M. pennsylvanicus* and *P. maniculatus*, and *P. intermedius* and *P. maniculatus* were also captured together less frequently than expected ($\chi^2 = 4.3$, 4.1 and 5.9, respectively, $P < 0.05$) but these differences (and all other species interactions) were not as great as the previous ones.

Discussion

Habitat associations of small mammals are difficult to interpret because habitat categories are somewhat arbitrarily defined and the recorded presence or abundance of a species within a given area can depend on a number of non-habitat factors such as sociality, dispersal and trappability. However, a number of generalizations may be made about the habitat associations of small mammals in the Kananaskis Valley.

All five species showed greater abundances in some habitats than others. *Clethrionomys gapperi* was most abundant in open canopy Spruce-Fir forest, *M. pennsylvanicus* was most abundant in subalpine meadows, *P. intermedius* was most abundant in coniferous riparian areas, *P. maniculatus* was most abundant in talus and rockfields and *M. longicaudus* were most abundant in subalpine meadows and deciduous riparian areas. These data generally agree with the habitat associations described by Salt and Clarke (1979) for the upper Kananaskis Valley (Kananaskis Park), but differ considerably from the findings of Mill and Anderson (1980). However, the latter study was based on only 99 small mammals caught primarily in grassland habitats.

These data show some similarities with comparable data from Kluane, Yukon (Krebs and Wingate 1976). Both areas are dominated by *Peromyscus* and *Clethrionomys* and both areas show yearly differences in abundances within habitats. *Microtus longicaudus* and *P. intermedius* were most abundant in similar habitats (subalpine meadows vs. subalpine tundra and riparian coniferous vs. willow, respectively) in both areas. However, some differences in habitat associations were evident between areas. *Clethrionomys rutilus* was most abundant in closed spruce-birch forest at Kluane while *C. gapperi* was most abundant in open spruce-Subalpine Fir at Kananaskis. *Peromyscus maniculatus* was most abundant in closed spruce-Buffaloberry and talus and rockfields at Kluane and Kananaskis, respectively. *Microtus pennsylvanicus* was most abundant in marshes and subalpine meadows at Kluane and Kananaskis, respectively. In addition, niche breadths were generally broader at Kananaskis than Kluane, although *P. maniculatus* and *Clethrionomys* had the highest (and *M. pennsylvanicus* the lowest) niche breadths on both areas. Niche overlap was highest between *M. pennsylvanicus* and *Synaptomys borealis* at Kluane but between *M. longicaudus* and *P. intermedius* at Kananaskis. These data indicate that the factors responsible for habitat segregation are likely different between these areas; relationships evident among species in one area are not applicable to other areas.

The small mammal fauna of the Kananaskis Valley was clearly dominated by *P. maniculatus*. This dominance (43% of all captures) was due in part to its wide use of habitat types (niche breadth = 0.77 over all years) as well as its abundance (e.g. 6.3 per 100 trap nights in talus and rockfields) within certain habitats. *Clethrionomys gapperi* had a narrower niche breadth (0.53) than *P. maniculatus*, but was also abundant within certain habitats (e.g. 6.6 per 100 trap nights in open canopy spruce-fir forests). *Microtus longicaudus* and *P. intermedius* had wide niche breadths (0.60 and 0.64 over three years, respectively), but their numbers were generally low in all areas. *Microtus pennsylvanicus* was present in few habitats (niche breadth = 0.37 over three years) and only in low numbers.

All species showed considerable yearly variation in numbers. *Clethrionomys gapperi* and *M. pennsylvanicus* were particularly low in numbers in 1981, even within their major macrohabitats. No explanation for these reduced populations is available. No clear trends between macrohabitat use (niche breadth) and abundance was evident within years. *Microtus pennsylvanicus* showed low niche breadth while *C. gapperi* showed an intermediate niche breadth in 1981 when numbers were low. *Phenacomys intermedius* showed relatively low niche breadth in 1981 when numbers were relatively low, but *P. maniculatus* showed essentially the same niche breadth in 1981 and 1982 (0.74 and 0.73, respectively) when abundance was least and greatest, respectively.

Macrohabitat segregation of these species appeared slight, as indicated by the high niche breadths and high degree of niche overlap between species. *Phenacomys intermedius* in particular showed high overlap with *C. gapperi*, *M. pennsylvanicus* and *M. longicaudus* in different years, while *C. gapperi* and *M. pennsylvanicus* consistently showed low niche overlap. These patterns reflect the diverse habitat use by *P. intermedius* and the different macrohabitat associations of *C. gapperi* and *M. pennsylvanicus* (primarily forest and meadow, respectively).

Despite the considerable degree of niche overlap as indicated by macrohabitat use, most species used different microhabitats or avoided interspecific contacts as indicated by multiple captures. Some microhabitat segregations, such as that between *C. gapperi* and *M. pennsylvanicus*, can be explained on the basis of low macrohabitat niche overlap, but this explanation was not universally applicable. There was no significant

correlation between microhabitat segregation values (as indicated by log transformed X values between species) and niche overlap values ($r = -0.53$; $P < 0.05$; $N = 10$ interspecific pairs) and some species pairs such as *P. maniculatus* and *P. intermedius* showed a low degree of association despite a fairly high niche overlap.

In general, the coexistence of non-hibernating mammals in the Kananaskis Valley appears related to a number of factors, including macrohabitat segregation (e.g. *P. maniculatus, C. gapperi, M. pennsylvanicus*), microhabitat segregation (e.g. *P. maniculatus* and *P. intermedius*), and different food habits (e.g. omnivorous *P. maniculatus* vs. herbivorous microtines). However, these arguments are not applicable to all species. *Phenacomys intermedius* and *M. longicaudus* are both herbivores with wide niches, high niche overlap and little microhabitat segregation. Further studies will be needed to determine the factors permitting their coexistence.

Acknowledgments

This investigation was part of a series of studies on the life history tactics of northern mammals supported by the Natural Sciences and Engineering Research Council of Canada and the Department of Indian and Northern Affairs. A. Holcroft, J. Schieck, C. Eckert and J. Duncan conducted most of the survey trapping. The use of the facilities at the Kananaskis Centre for Environmental Research (The University of Calgary) is greatly appreciated.

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Received 1 June 1983
Accepted 26 October 1984

Movements and Habitat Use In an Unhunted Population of Mountain Goats, *Oreamnos americanus*

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Movements, activity, home ranges and habitat use by Mountain Goats, *Oreamnos americanus,* were studied through monitoring of nine radiocollared individuals, June 1980 to August 1981, in Glacier National Park, Montana. The population was characterized by high density, large group sizes, low proportion of adult males, very small home ranges, and low kid productivity during two years of observation. Home ranges of adult billies ($\bar{x}$ = 2.8 km^2), mean movements per hour ($\bar{x}$ = 0.53 km per hour), and visits to a natural mineral lick ($\bar{x}$ = 9 per year) were significantly less than for adult nannies ($\bar{x}$ = 4.8 km^2, $\bar{x}$ = 0.99 km per hour, and $\bar{x}$ = 14 lick visits, respectively). Long movements to the mineral lick were influenced by weather. Lick movements were most likely in clear weather, after a recent clearing trend, and with duration since the last lick visit. Mountain Goats preferred alpine forb meadows, forb dominated outcrops, forested crops and lick habitat types. Associations between individual marked goats never exceeded 23%. A great deal of individual variation was observed for both billies and nannies in their associations with other marked individuals, the average size of groups, and the number of lick visits per year.

Key Words: Mountain Goats, *Oreamnos americanus*, ecology, movements, activity, habitat relations, unhunted populations.

Mountain Goat (*Oreamnos americanus*) population dynamics have proven an enigma to wildlife biologists (Eastman 1977; Chadwick 1983). Many populations have declined severely in the face of increased access and hunter harvests (Pendergast and Bindernagel 1977; Chadwick 1983). Several authors feel that as few as 5–10% of goat populations can be safely harvested (Adams and Bailey 1982) and in one study in Idaho all hunting mortality appeared to be additive (Kuck 1977). On the other hand, several introduced herds on new ranges have experienced population growth rates as high as 11% (Chadwick 1983). After peaking, these introduced herds have stabilized (Adams and Bailey 1982; Stevens and Driver 1978), and these stabilized and other established herds demonstrate little or no compensatory reproduction to hunter harvests. We report here on the movements, habitat use and sociality of a protected, high density, and relatively unproductive herd of Mountain Goats in Glacier National Park, Montana. The ecological information presented here was gathered incidental to monitoring and studies of Mountain Goats during reconstruction of U. S. Highway 2 through Glacier National Park.

Study Area

Studies were confined to Running Rabbit Mountain (32.7 km^2) located along the Middle Fork of the Flathead River in Glacier National Park (GNP), Montana. Elevations ranged from 1030-2150 m. Dominant features of the glaciated mountain are long, high ridgelines connecting sparsely vegetated peaks. Large cirques are carved into the upper north and east slopes below the ridgelines. Bedrock outcroppings are common on all slopes. Lower elevations support coniferous forests with shrubs dominating at mid-elevation. Ridgelines and upper cirques support grasses and alpine forb meadows. Mature Subalpine Fir (*Abies lasiocarpa*) exist in treeline stands and on protected outcrops where they escaped extensive forest fires in 1910 and 1926. Average annual precipitation ranges from about 76 cm at lower elevations to about 180 cm along the adjacent Divide of the Flathead Range. Fifty to 80 percent of the annual precipitation falls as snow.

Dominant vegetation cover was identified from ground surveys, and aerial black-and-white and high altitude infra-red photos and acreages roughly estimated using gridded overlays. Twelve cover vegetation types and their estimated percent cover (%) of the Running Rabbit Mountain study area are:

1. *Coniferous forest* (55%) — Occurs mostly on lower slopes and is codominated by Lodepole Pine (*Pinus contorta*), Western Larch (*Larix occidentalis*) and White Spruce (*Picea engelmanni*). The majority of conifer forest represents the Subalpine Fir/Queen's Cup habitat type with Dwarf Huckleberry and Menziesia phases: *Abies lasiocar-*

pa/Clintonia uniflora h.t., *Vaccinium caespitosum* and *Menziesia ferruginea* phases following R.D. Pfister, B.L. Kovalchik, S.F. Arno, and R.C. Presby (1977. Forest habitat types of Montana. USDA Forest Service Technical Report INT-34. Intermountain Forest and Range Experiment Station, Oregon). Most of the forests burned in 1910 and 1926.

2. *Shrub type* (13%) — Includes Alder (mostly *Alnus sinuata*) stands, tall stands of Serviceberry (*Amelanchier alnifolia*) and Mountain Maple (*Acer glabrum*) on mesic lower slopes and draws, and shorter shrub stands (Serviceberry, *Ceanothus velutina, Prunus virginiana melanocarpa*) mixed with grasses on drier slopes at mid-elevations.
3. *Forest/shrub* (4%) — Mixed shrubs and seral forest growth primarily resulting from 1910 and 1926 fires.
4. *Subalpine Fir/Beargrass krummholz* (5%) — A park-like forest type with extensive ground cover of Beargrass (*Xerophyllum tenax*). alpine forbs and grasses and scattered Subalpine Fir which vary from moderately large specimens on more protected sites to highly stunted, and flagged individuals on more exposed sites.
5. *Bunchgrass ridges* (3%) — Isolated stands on Bluebunch Wheatgrass (*Agropyron spicatum*), with *Calamogrostis canadensis, C. rubescens,* and *Dryopteris austraica* occur on the driest, mid and low elevation axillary ridges.
6. *Alpine forb meadow* (3%) — Occupies mesic sites at or above treeline such as on the sides and bottom of cirque basins and around retreating snow banks. *Carex* spp. and *Poa alpina* mixed with a wide variety of mesic forbs such as *Archillea millefolium, Anemone multifida, Polygonum* spp., *Penstomon* spp., *Gentiana* ssp., *Mimulus tilingi, Heliotrope curassavicuum,* and *Potentilla* spp.
7. *Exposed outcrops* — Outcrops are primarily Missoula mudstone and Missoula limestone which were exposed during uplifting by the Lewis Overthrust and later glaciated (Ross 1959). Outcroppings are extensive, but the majority are relatively small (5-15 m high) and scattered with extensive mantling of the adjacent mountain sides with soil, talus, and glacial debris. *Bare bedrock* (9%) occurs primarily at the higher elevations. The *talus-scree type* (1%) is common below exposed formations. *Forested outcrops* (3%) are dominated by scattered but in many cases large individual subalpine fir since these sites were protected from most fires. *Shrub-covered outcrops* (2%) are prevalent at lower elevations and *forb-covered outcrops* (2%) at and above treeline. The *lick area* (< 1%), a large river-cut face at the mountain's base is situated at 1025 m and composed of gypsum, Kierserite, and other sulfates.

The GNP goat population is protected from hunting and encounters with humans are very rare. Individual goats, however, are subjected to highway and road-associated human disturbances when they travel to the mineral lick (Singer 1978). Goats from Running Rabbit Mountain freely intermixed at the mineral lick with goats traveling from the Flathead National Forest (FNF) directly to the south and west (Figure 1). The FNF goats crossed the Middle Fork of the Flathead River to reach the lick. However, in about 1978 a new mineral lick immediately across the river was either uncovered by river action or newly discovered by goats. The two herds are now largely separated; only two river crossings were observed in 1980 and four in 1981 by groups of one to three individuals. In contrast to the Running Rabbit Mountain (GNP) herd, the adjacent FNF herd is hunted, occurs at much lower density and in smaller, more scattered groups, and occupies a more forested range with fewer outcrops. Outcrops in the National Forest are primarily of Siyeh limestone formation and tend to occur at higher elevations and to form fewer goat ledges since the rock is more resistant to weathering and is folded rather than stepped (Ross 1959). As a result, there is less winter range in the National Forest than on Running Rabbit Mountain.

Methods

Mountain Goats were captured in Clover-style deer traps placed along regularly used trails near the Walton goat lick. Captured animals were immobilized with Ketamine hydrochloride (about 7.7 mg/kg of body weight) and Xylazine hydrochloride (about 0.15 mg/kg of body weight). Eight animals were radio-collared (AVM Instrument Co., Champaigne, Illinois) and another three animals instrumented with heart-rate implant-radio-collar packages (Wyoming Biotelemetry Inc., Loveland, Colorado). Implants included a heart-pulse detection and short-range transmitting package (20g) inserted just below the skin surface at the sternum (Cupal et al.) 1976; Cupal 1977; Weeks et al. 1977). Two stainless steel electrocardiogram (EKG) electrodes, 25 cm and 8 cm long, were placed on each side of the sternum below the skin. Freddy (1977) described the surgical procedures. A repeater receiver and long range transmitter were packaged in the neck collar. The heart rate signal was picked up by a receiver/microprocessor, transmitted to a D/A amplifier and either displayed on a dual-channel Rustrak recorder at distances < 1 km or audio detected and hand calculated at distances of 1-2 km. In the latter cases, heart rate was calculated over 10-second intervals and expressed as beats per

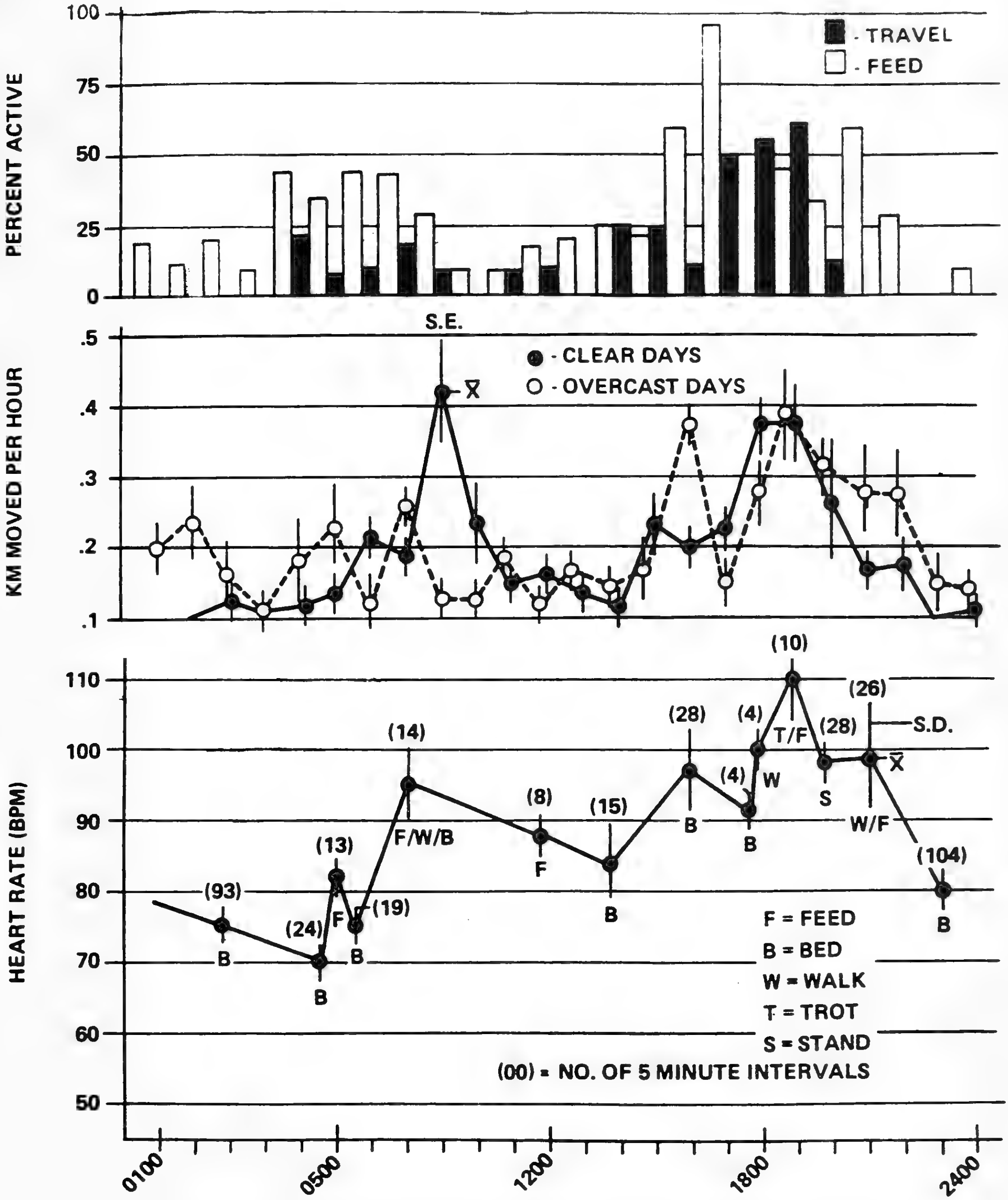

FIGURE 1. Daily activity patterns of Mountain Goats, June through August, in Glacier National Park, Montana. TOP = Percent of large groups (N = 7 groups, $\bar{x}$ = 42 goats per group) traveling or feeding during seven continuous 24-hour watches. CENTER = Mean movements per hour for radio-collared goats (N = 21 continuous 24-hour long watches; 14 watches were sunny days and seven had heavy overcast). BOTTOM = Daily heart rate for nanny No. 13, 21 June, 1980. Each circle represents 5-minute interval(s) with no change in heart rate.

minute (bpm) following MacArthur et al. (1979).

Radio-collared animals were located at one or two week intervals from the road system which encircles 70% of the study area. Goats were normally located visually using a 20-6-x spotting scope after two directional locations were made. For less than 10% of the locations, primarily those made during dark nights or when goats were in heavy cover, locations were by triangulation alone.

Activity patterns were sampled during 24- or 48-hour continuous monitorings of individual animals, conducted irregularly from June through August of 1980 and 1981. Three to six animals were simultaneously monitored during each session. Monitoring was conducted from a high peak where visual contact could be maintained except during dark nights. Moonlight allowed observation during some nights.

For each animal location we recorded: Universal Transverse Mercator (UTM) location, elevation (from topographic maps), slope, aspect, weather conditions, temperature and relative humidity, cover vegetation type, topographic moisture gradient, primary soil succession, number of goats in a group and group composition, proportion of group involved in major activity types; and for outcrop locations: rock formation, outcrop type (blocked, stepped, folded), a visual estimate of average number of goat negotiable ledges per vertical 10 m, and number of outcrops in a circular km² surrounding the goat-occupied outcrop. We sampled daily movements by recording straight line distances between sequential hourly locations.

Home ranges were calculated by two methods: 1) by connecting the outermost location points with straight lines — the commonly used minimum convex polygon method of Mohr (1947); and 2) by the minimum polygon method of Stickel (1954) which tends to eliminate more area with no radio locations. Cover vegetation types were mapped from extensive ground surveys, aerial black-and-white photos, and high altitude infra-red photos. Area was estimated with gridded overlays (1:63360 scale maps). Location error due to plotting goat locations on maps of this scale was estimated to be ± 20 m. Cover-vegetation stands smaller than 2-4 ha were not accurately mapped by our technique although they may be ecologically important, therefore habitat relations depict only general trends. Data from both the semi-weekly radio-locations and continuous monitorings were pooled for habitat analysis. Both were conducted randomly with respect to weather, and in addition, the continuous hourly monitorings were unbiased with respect to time of day. Utilization-availability analysis followed Neu et al. (1974).

Individual goats were classified as kid, yearling, two-year old, adult nanny, and adult billy from relative body and horn size and conformation (Brandborg 1955; D.H. Chadwick 1973. Mountain Goat ecology and logging relationships in Bunker Creek drainage of western Montana. Montana Fish and Game Project, W-120-R-3,4. 262 pp.). Ages of goats were estimated from horn rings (Brandborg 1955; Foster 1978) when in traps or when approached to < 2 m distance. Sex/age classifications of the GNP herd were based upon the single highest count in a year since all or nearly all of the entire herd occasionally were together. Minimum numbers were conservatively estimated by the highest counts plus adding any marked individuals absent. The National Forest goats, however, were more dispersed and were observed in small groups of 1-4 throughout their range and at the new lick. We suspected that they visited the new lick only once per year, lick visits were for several days but all visits were < 2 weeks, similar to goat use of licks described by Hebert and Cowan (1971). We estimated numbers and sex/age ratios for the FNF herd by adding together the highest counts during each two-week interval. This likely eliminated any duplicate counts of female/young/subadult individuals (Hebert and Cowan 1971). We did not calculate a male ratio, however, because they are independent in their visits and male lick times are likely shorter.

Records of temperature, relative humidity, barometric pressure, and weather class (clear, partly cloudy, heavy overcast, rain, snow) were recorded late each afternoon during summer at the Walton Ranger Station (2 km from the mineral licks).

Results and Discussion

Density

Minimum population estimates for Running Rabbit Mountain were 90 in 1975, 90 in 1980 and 107 in 1981. The median estimate of 96 is equivalent to 2.9 goats/km². When calculated for area of observed use only, the density is 15.4 goats/km². We roughly approximated the National Forest herd at 60 animals. Their range was about 60 km² based upon location of 28 goats observed during foot surveys of 1975 or 1 goat/km² and about one-third the density of the GNP herd.

Running Rabbit Mountain densities are higher than most reported figures; 0.7-2.5 mountain goats/km² (Holroyd 1967; Hjeljord 1973; Rideout 1974; Hebert and Turnbull 1977; D.H. Chadwick 1973. Mountain Goat ecology and logging relationships in Bunker Creek drainage of western Montana. Montana Fish and Game Project, W-120-R-3,4. 262 pp.). For area of observed goat use only, the Running Rabbit Mountain density was 15.4 goats/km², or 1.2-5.0 times higher than the next highest reported figures;

2.8 goats/km^2 in the central GNP (Chadwick 1977), 7.7 goats/km^2 on Kodiak Island, Alaska (Hjeljord 1973), and 12.8 goats/km^2 in Olympic National Park (Stevens and Driver 1977). These latter two figures are for expanding, introduced populations. High precipitation may be a factor in density — three of the four highest density figures are for coastal populations, and our study area is wet relative to most of Montana. Kuck (1977) and Chadwick (1977) felt that the size, slope and distribution of outcrops, and ledge formation on outcrops influenced Mountain Goat densities. Our GNP study area was typified by numerous and small but evenly distributed outcrops. Outcrops were lower in elevation and more regularly-stepped than in the adjacent FNF.

Sex and Age Characteristics

The GNP population of Mountain Goats was characterized by low kid production, a low male ratio, and possibly low survival of kids. Our basis for these statements includes.

1) During 1980 and 1981, the Running Rabbit Mountain population kid production was about half, and percent of twins about one-eighth, that of the immediately adjacent FNF herd (Table 1). Most kid:100 females ratio average 50-70 kids:100 females (Brandborg 1955) with 20-39 kids:100 females considered low (Hjeljord 1973; M.J. Rognrud 1946. A preliminary investigation of Mountain Goats in the Continenal big game movement unit, Sun River-Flathead River, Montana. P-R-Project 1-R, Montana Fish and Game Department. 62 pp.; Brandborg 1955) and 86-97 kids:100 females high (Hanson 1955; Stevens and Driver 1977). Five reports of twinning rates averaged 6% (Brandborg 1955; Anderson 1940; Stevens and Driver 1977).
2) Survival of very young kids was apparently low in the Running Rabbit goat herd. In summer 1980, we handled 11 adult nannies, four had kids, four were apparently barren, while three had distended udders suggesting that they had lost kids prior to their capture.
3) The male ratio of 26-28 males: 100 females in the Running Rabbit herd is one of the lowest reported. Most adult billies: 100 adult nannies ratios are 56-87 (73-87 — Brandborg 1955; 74 — Cowan 1950; 87 — Anderson 1940; 56 — Stevens and Driver 1977), although Chadwick (1977) and Rideout (1974) reported low ratios of 27-56 and 23-44, respectively. Geist (1964) observed billies to travel to nanny/young groups and male ratios to increase during the rut. Classifications of about one-half the herd during the 1980 rut revealed no rise in male ratios nor did more extensive winter range classifications. However, rut observations were limited due to foggy weather and the possibility of a short-term ingress of billies from peripheral areas is possible. Our male ratio data, however, is comparable in method to the above authors with the exception of Geist (1964).
4) We crudely calculated mean age of nannies older than one year to be 4.8 years and 3.3 years for billies. Little published age structure data are available for comparisons, although the GNP nannies were older than 50 handled by Stevens (1983:200) in a stabilized herd. Our calculations were based upon subadult classification and visual aging of horn growth rings at < 2 m in 23 females (about 55% of total herd, nine were handled) and 12 males (44% of the herd). Aging Mountain Goats by horn rings may result in underestimates, particularly in nannies (Foster 1978). In addition, we may not have visually observed a few growth rings covered by hair at the base of the horns, further strengthening our conclusion the GNP animals were older on the average than were Stevens (1983).

TABLE 1. Sex and age composition of two Mountain Goat herds under study in Glacier National Park (GNP) and the Flathead National Forest (FNF), Montana. The two herds are adjacent but largely discrete.

Herd	N	Kids: 100 ♀	Yearlings: 100 ♀	2-year old: 100 ♀	♂: 100 ♀	% of twins
Running Rabbit Mountain (GNP):						
1980	79	43	20	15	28	5
1981	98	42	30	6	26	3
Flathead National Forest (FNF):						
1980	31	92	50	17	—	33
1981	59	100	47	26	—	29

Our information on mortality is sketchy and explanations for the radically different kid production are speculative. The GNP herd is protected, poaching losses were believed to average <0.5 goats/year, highway losses < 0.5 goats/year, little predation is suspected, although deaths from avalanches have been reported and could be substantial in some years. The same factors operate on the FNF herd, except that limited sport hunting also occurs. Likely, the GNP herd stabilized while the FNF herd was increasing. Adams and Bailey (1982) reported a 47% decrease in reproductive success and possible increased winter mortality of kids in Colorado as an introduced goat population peaked and plateaued. Population stability predicts higher mortality in neonatal young and higher adult male mortality or dispersal of subadult males (Caughley 1976).

A second explanation for the observed productivity

differences is an extension of Geist's (1971) view of high and low "quality" populations of Bighorn Sheep (*Ovis canadensis*). Chadwick (1977) hypothesized that the highest densities of Mountain Goats which inhabit excellent winter range (e.g., central GNP, Montana) similar to that of the Running Rabbit herd produce relatively low but consistent kid crops, while herds inhabiting more forested winter range with much less exposed bedrock and deeper snows (i.e., Swan Mountains, Montana) similar to our FNF study herd, produce more widely fluctuating kid crops which are more dependent upon winter conditions.

Home Ranges

We radio-collared two males and six females and instrumented another three females with heart rate-implant radio-collar units. Two of the heart rate systems failed within the first week, but a third functioned for 10 months. One radio-collared billy (nine years old) died of unknown causes in December 1980 after seven months. Consequently, nine animals provided radio-location data for an average of 11.6 months each (range 7-15). We conducted 34 location sessions on these nine animals during 15 consecutive months (June 1980-August 1981) or 2.3 locations/month/goat (range 1-5 per month) which resulted in 200 individual animals locations. In addition, 21 complete 24 hour monitoring periods in 1980 and two partial periods in 1981 on all nine goats resulted in 566 additional locations for a combined total of 766 radio locations.

Minimum home ranges (minimum polygon) for Mountain Goats on Running Rabbit Mountain were very small (4.4 ± 1.1 km^2, $x \pm$ S.D.). Running Rabbit ranges were only about one-third the size of ranges reported elsewhere in Montana (Table 2). The convex polygon method is used in Table 2 to be consistent with the other reports, however the minimum polygon method is felt to better represent Mountain Goat ranges and is used in later analyses. The convex polygon method added areas inhospitable to travel by Mountain Goats, and that to our experience were areas without sightings of goats, shed hair or scat, or goat trails. Also, the convex polygon method was not well suited for comparisons since it added inconsistent areas to the minimum polygon calculations ($106 \pm 35\%$ more area, range 64-174%). Most home ranges were linear in shape because of movements of goats along fixed mountain crest trails. Linear shapes contributed to problems with the convex polygon method. We reported only plane home range estimations in order to be consistent with other authors, although in such precipitous terrain this underestimates actual area.

Home ranges of all nine radio-collared goats overlapped extensively. All goats shared a common alpine summer range and few differences in winter areas. Two collared individuals (No. 9, a nine year old male, and No. 22, a four year old female) moved during November 1980 to a 2.7 km^2 winter range immediately north-west of the summer alpine range while the remaining seven radio-collared animals moved to a larger, 4.5 km^2 range immediately south and east of the summer range. When snows are deep, these two winter ranges could be isolated, but during the mild winter of 1980-81, some goats moved between both winter ranges. One goat (No. 22) switched areas in January 1981. Also, goats moved up from both winter areas in 1981 and across the ridgeline peak trail to make unusual wintertime visits to the lick. Similarly, Rideout (1974) found that Mountain Goats continued to use their summer/fall range during a mild winter, but did not during a severe winter. Other authors (Anderson 1940; Brandborg 1955; Kerr 1965) reported larger separations (several km) between summer and winter ranges than we observed.

Home ranges for adult billies, 2.8 ± 1.1 km^2, were significantly smaller than for nannies, 4.8 ± 0.6 km^2 (Mann-Whitney U test, $U = 14$, $p < 0.10$, Table 3). Rideout (1974, Table 2) found subadults to have the largest home ranges, but he observed adult nannies to have only slighter large home ranges than billies. We did not sample subadult home ranges.

Home ranges of adult billies overlapped extensively with nannies. Also, we detected no significant habitat separations. Both sexes utilized the same feeding areas and ledges, and were frequently observed in mixed sex groups. This contrasts sharply to other studies of

TABLE 2. Home range sizes of Mountain Goats for three areas in Montana calculated with the convex polygon method of Mohr (1947).

Annual Home Range Size (km^2)					
Adult Billy	Adult Nanny	2-year olds	Yearling	Area of Montana	Source
22.0	14.0			North central	Thompson (1980)
21.5	24.0	31.1	48.3	Sapphire Mountains	Rideout (1978)
6.3	8.9	12.6		Glacier National Park	This study

Mountain Goats, where outside of the rut adult males are found peripheral to female/young groups (DeBock 1970; Chadwick 1973 [unpublished, see above]; Rideout 1974; Smith 1977; Geist 1964) and in "marginal" habitats (Kuck 1977; Foster 1978). Billies apparently did not cross from range to range during the rut as Geist (1964) observed, although our sample of billies was limited.

The high densities of Mountain Goats on Running Rabbit Mountain predicts greater sexual separations than we observed (Foster 1978), and high rates of between-sex aggression if food sources are limited (Petocz 1973; Rideout and Hoffman 1975). Either food resources were very abundant on Running Rabbit Mountain or the confined home ranges forced a closer not-rut association of sexes, as Schaller (1977:322) predicted for extreme cliff dwelling Caprids. Billies were not consistent companions with individual nannies nor were they with other billies.

Movements

Adult billies moved less than nannies (0.45 ± 0.22 versus 0.97 ± 0.19 km/hr, N = 23, 24-hour monitorings, U = 14, $P < 0.10$) but the frequency of visits to the mineral lick did not differ between sexes ($p > 0.90$, Table 3). Mean movements per hour were significantly correlated to home range size in individual goats (Spearman rank correlation, ($r_s = 0.50$, df = 8, $p < 0.10$), but not to the number of visits to the mineral lick ($r_s = 0.33$, $p > 0.90$).

Nursing nannies did not differ from non-lactating nannies in home range size, movements per hour, or visits to the mineral lick ($p > 0.90$, N = 14 kid producing seasons for seven individual nannies). Three of the four most mobile nannies in terms of movements per hour were without kids. A less mobile nanny (No. 14) produced three kids (twins and one kid) during the study. However, the most mobile nannies (No. 24) produced one kid each of both study years.

Movements of the two billies varied tremendously. Billy No. 8 moved 47% as far per hour, visited the lick 29% as often, and its home range was 55% the area of No. 12, although it was a larger animal. O'Connor (1974) describes solitary but large and fat Dall Sheep (*Ovis dalli*) and Bighorn Sheep rams with very localized summer movements. We conducted no continuous monitorings during the rut when perhaps sexual differences in movements would vary. Also, we radio-collared no subadult males — potentially a more mobile class (Chadwick 1973 [unpublished, see above]).

Peaks in movements occurred for 0700-1000 hours and from 1500-2000 hours on clear sunny days (Figure 1). Rideout (1977) reported similarly-timed bimodal daily activity peaks. Mean movements per hour in radio-collared individuals were correlated to the percent of unmarked groups moving (traveling and feeding) for the same hour ($r^2 = 0.42$, d.f. = 23, $p < 0.01$) and to the mean hourly heart rate of the single implanted nanny ($r^2 = 0.42$, d.f. = 23, $p < 0.01$). Movements were more variable on overcast days (Figure 1). We conducted no winter 24-hour monitorings.

Heart rate readings reached minimums and movements approached zero from 0100-0600 hours (Figure 1). Long movements during the night by Mountain Goats are unlikely (Rideout 1974) as is also the case in the closely related Tahr (*Hemitragus jemlahicus*) and Chamois, *Rupicarpa rupicarpa* (Schaller 1977).

Heart rates for nanny No. 13 were higher for the same activities during the two daily activity peaks than at other times, suggesting possible arousal or enhanced sensitivity at those times (MacArthur et al. 1979). More individuals were observed traveling, and

TABLE 3. Movements and home range size for nine radio-collared Mountain Goats, Glacier National Park, June 1980-August 1981.

Animal #	Sex	Est. age	With Kids 1980	With Kids 1981	# Radio locations	Home range size (km^2)	Mean km moved/hr.	No. visits to lick, 1980-81
12	M	8			119	3.63	0.611	14
8	M	9			31	2.01	0.288	4[2]
17	F	2			113	5.04	1.085	25
3	F	3		*	72	4.51	1.150	11
24	F	3	*	*	72	4.85	1.198	14
6	F	4			125	5.31	1.015	21
13	F	4	*		87	5.75	0.737	14
22	F	4		*	89	4.02	0.739	20
14	F	7	*[1]	*	58	4.16	0.876	3

[1]A set of twins

[2]No. 8 died half-way through the study. For purposes of comparisons, we assumed he would have also made two lick visits in 1981.

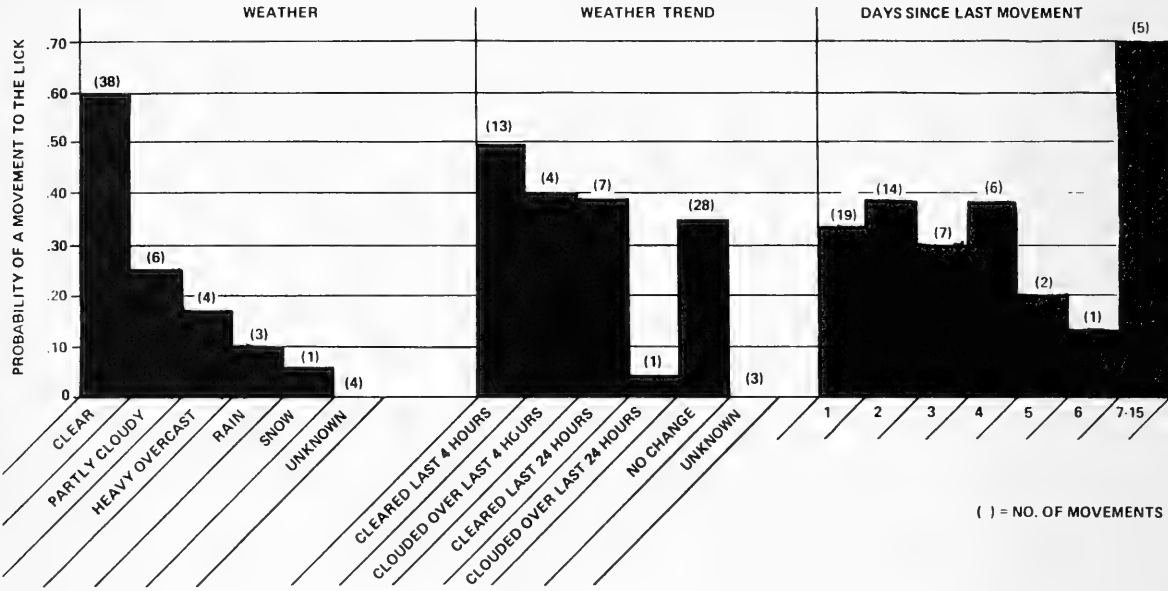

FIGURE 2. Probability of a movement by Mountain Goat(s) to a mineral lick (probability = no. of lick visits under the observed conditions/ no. of days with those conditions) in Glacier National Park during the summers of 1980 and 1981. Weather at arrival to the lick, weather trend, and days since the last observed lick visit was compared for 56 lick visits during a total of 159 days of continuous observation for the two summers.

the highest average heart rates were observed, during the afternoon (1500-2000 hr) peak. Also, longer movements to the mineral lick were likely to be initiated then (Singer 1978).

We observed 56 arrivals of Mountain Goats at the mineral lick during 159 days when weather was recorded, June-August of 1980 and 1981. We tested the hypothesis that lick visits were random with respect to weather by comparing days with visits (observed) to all days with the same weather conditions (expected) using Chi-square tests. Lick visits differed from the expected for weather class, change in weather, and days since the last lick visit ($p<0.05$), but not for temperature, relative humidity, barometric pressure, changes in barometric pressure, or number of hours of sunshine that day (Figure 3). The probability of a movement to the lick was highest on a clear day, when the weather had cleared in the last four hours, and when seven or more days had elapsed since the last lick visit by goats. Similarly, Hebert (1967) observed more lick visits by Mountain Goats immediately after storms cleared, and U. P. McCrory (1965 [Preliminary report on study of natural salt licks used by Mountain Goats and Bighorn Sheep in Jasper National Park. Unpublished report, Canadian Wildlife Service, Edmonton. 55 pp.]) observed few goats on a lick during rain. On five occasions we observed goats make obvious intentions to travel to the lick one day before lick arrivals, further suggesting a build-up in lick drive.

During extended periods of fog and rainy weather in summer, Mountain Goats moved down to the same low elevation cliffs used as winter range. These cliffs were about 2.2 km and 690 m below most summer range. Goats recognized major weather changes. We observed five rapid (60-120 minutes) movements of the majority of the herd down from alpine habitat as severe storms approached, and six reverse movements up from low cliffs during a clearing trend. Similarly, during clear weather Fox (1977) observed Mountain Goats at higher elevations, closer to ridgelines and further from forest cover.

Habitat Use

Subalpine Fir/Beargrass krummholz, alpine forb meadow, the mineral lick, and all five outcrop types were preferred by Mountain Goats (Table 4, $p<0.05$). When considering the area of observed goat use only, alpine forb meadow, forb covered outcrop, forested outcrop, and the lick were preferred (Table 4). Mountain Goats tended to use the alpine forb type when there was no precipitation, to seek cover such as Krummholz and forested outcrop during precipitation particularly under the larger Subalpine Fir trees,

TABLE 4. Radio-locations of nine Mountain Goats in cover vegetation types on all of Running Rabbit Mountain Range (3266 ha) and in the 622 ha portion of that range observed to be used by goats. A + indicates preference of a specific type, and a — indicates avoidance as suggested by use — availability analysis (Neu et al. 1974, $p < 0.05$).

Vegetation type	No. locs.	Confidence interval on locations	Proportion of vegetation type on entire range	Preference/ avoidance	Proportion of vegetation type goat use area	Preference avoidance
Forest Shrub Types						
Conifer	5	$-0.002 < 0.006 < 0.014$	0.552	—	0.241	—
Shrub	49	$0.039 < 0.064 < 0.089$	0.130	—	0.147	—
Forest/Shrub	12	$0.003 < 0.016 < 0.029$	0.044	—	0.042	—
Abies/Krumm.	103	$0.099 < 0.134 < 0.169$	0.050	+	0.106	
Grass Types						
Bunchgrass slope	2	$-0.002 < 0.003 < 0.008$	0.028	—	0.035	—
Alpine Forb. meadow	119	$0.119 < 0.155 < 0.191$	0.030	+	0.087	+
Rock Type						
Bedrock	121	$0.121 < 0.158 < 0.195$	0.085	+	0.170	
Talus, scree	25	$0.015 < 0.033 < 0.051$	0.009	+	0.022	
Forb/outcrop	89	$0.082 < 0.114 < 0.146$	0.019	+	0.011	+
Shrub/outcrop	50	$0.040 < 0.065 < 0.090$	0.022	+	0.067	
Forested outcrop	69	$0.061 < 0.090 < 0.119$	0.027	+	0.050	+
Lick	124	$0.125 < 0.162 < 0.119$	0.004	+	0.022	+
TOTAL	766		3266 ha		622 ha	

and to use talus during both sunny, dry days and in winter when talus was readily windswept. Outcrops were used during all weather conditions.

Mountain Goats utilized only 19 percent (6.22 km^2) of Running Rabbit Mountain, based upon 766 radio-locations and 11 observations on non-marked groups of goats peripheral to the radio-locations. Only 0.6% of the radio-locations were in coniferous forest, which comprised 55% of the study area. Only 39% of the key summer habitats were utilized by goats (only 66% of the Subalpine Fir Krummholz, 55% of the alpine forb meadow, 7% of forb dominated outcrop). The areas of summer habitat by Mountain Goats were on the southwest half of the mountain closest to the lick. The remaining alpine areas of the mountain appear similar, and we suspect the lick drive restricted goats in summer.

The mild winter of 1980-81 was characterized by significant snowfalls followed by subsequent thaws. Each time that snow depths declined, Mountain Goats moved back up in elevation. This pattern was demonstrated by a significant negative correlation between estimated mean monthly snow depth and mean monthly elevation for observations of radio-collared goats ($r_s = 0.59$, $p < 0.05$).

Larger group sizes of Mountain Goats occurred from July to August when goats used the highest and more open alpine habitats. Group sizes (away from the lick) were correlated to elevation ($r_s = 0.61$, $p < 0.05$).

Although used extensively during all seasons, selection and use of outcrops varied between summer and winter. On sunny days during the summer, goats often were found in cirques. As the sun's angle changed, they moved across the cirque in order to continue to bed on shaded outcrops. Goats selected larger outcrops in June-August in order to avoid direct sunlight ($\bar{x} = 48 \pm 40$ m high) than in September-May ($\bar{x} = 19 \pm 13$ m). In winter, goats occupied habitats with small, but more numerous outcrops. Goats on outcrops were found with an average of 13 outcrops/km^2 around them in winter, but only 5.4 in summer (t test, $t = 1.7$, $p < 0.10$). Also more outcrops selected in winter were stepped (75%) than summer selections (29%) and had more ledges per vertical 10 m ($\bar{x} = 2.6$) than summer selections ($\bar{x} = 0.18$). Likely winter forage availability — browse, grasses, sedges — was optimized on smaller, stepped outcrops with more ledges. Also, during our study, goats were frequently observed feeding on top of, on the sides of, and on, brushy slopes in between small, but clustered, outcrops. Perhaps, in a severe winter deeper snows would force goats on the study area to use larger and steeper outcrops (Smith 1977) and to restrict more of their time to ledges on the outcrop face.

Social Gatherings

Radio-collared Mountain Goats were observed in 285 different groups; 91 while at the lick, 68 on summer range, and 52 on winter range. An additional three goats (one 2-year male, one adult male, one adult female) were individually recognized by broken horns while at the lick 23 times. These latter individu-

TABLE 5. Group size and associations between radio-collared Mountain Goats in Glacier National Park, June 1980-August 1981 (N = 285 radio-located groups).

Animal no.	Age	Group observations[1]	Mean group size ± S.D.	Radio-located groups[2]	Percent association with other radio-collared goats								
					None	8	12	3	6	13	14	17	22
Males													
8	9	6	15.6 ± 31.2	13	54								
12	8	31	13.1 ± 19.7	58	31	3							
Lft. horn[3]	2	10	17.4 ± 26.3	—	—								
Both horns	adult	3	9.0 ± 4.6	—	—								
Females													
Rt. horn	adult	10	32.3 ± 29.7	—	—								
3	2	24	24.5 ± 26.9	50	14	2	7						
6	3	29	28.2 ± 27.8	79	8	1	10	15					
13	3	26	30.6 ± 26.7	80	16	1	16	14	16				
14	4	15	13.8 ± 13.2	23	61	0	0	9	9	13			
17	4	42	20.5 ± 18.4	83	20	1	14	8	20	23	4		
22	4	25	34.4 ± 26.9	55	40	0	7	5	20	20	0	20	
24	7	18	31.2 ± 25.9	58	41	0	12	5	14	17	4	22	14

[1]Includes all groups both on the lick and the range for that individual where the entire group could be counted.
[2]Includes all of the above groups plus instances where radio signals were obtained but not all of the group observed.
[3]Indicates naturally recognizable individuals through broken or deformed horns.

als could not be consistently recognized while on the range due to the longer observation distances there. Data from them was used only for group size comparisons (Table 5).

Group size, number of visits to the lick, and number of associations with other radio-collared goats were potential indices to social tendency in individual goats. The least social nanny and billy visited the lick less, were in the smallest groups, and were found with other radio-collared goats less than other individuals of their sex. However, lick visits, mean group size, and individual associations were not statistically correlated (r_s, $p > 0.90$). All radio-collared goats were subjected to the same highway disturbances; however, the frequency and duration of lick visits was influenced by the level of man-caused activity (Singer and Doherty, in preparation) and perhaps goats reacted differently to human disturbances.

Billies varied greatly in their social tendencies. Male No. 8, for example, visited the lick only two times in 1980, was typically solitary or in a male-only group and was located infrequently with other radio-collared goats (Table 5). At least two other billies were similarly less social; one (or more) solitary males frequented part of the alpine range. Another, naturally recognizable, billy visited the lick only three times in 1981. Two other billies (No. 12 and a recognizable two-year old) visited the lick more often (9 and 10 times in 1981, respectively), were rarely solitary, and were observed in larger groups and more mixed sex groups (Table 5). In contrast, Brandborg (1955), Chadwick (1977), Kuck (1977), and Smith (1977) felt that adult billies were primarily solitary or occasionally found with other males. Only Hebert (1967) reported substantial billy occurrence in female/young groups outside of the rut. While sexual segregation may not have been absolute in the other studies, we observed some individual billies in nanny/young groups during one-half or more of all their sightings.

Nannies were observed in larger groups than billies (female, $\bar{x} = 26.9 \pm 6.9$ versus male, $\bar{x} = 13.8 \pm 3.6$), but social tendencies also varied greatly between individual nannies. The least social nanny was No. 14, who was found in groups 52% smaller on the average, and in the absence of other radio-collared goats 20% more often than other nannies. No. 14 produced kids both years, but equally productive nannies (e.g. No. 24) were more social. The most social nannies (Nos. 3, 6, 17, 22) were only two to four years old, yet the least social nanny (No. 14) was also four years old.

Individual associations between goats were very low (Table 5), similar to the observations of Stevens and Driver (1977). Association between pairs of nannies ranged from 0-23% and averaged 13.0 ± 6.8. Nannies with the highest individual associations (Nos. 6, 13, 17, 22, 24) also visited the lick the most and were found in the largest groups — we suspect the higher individual associations were merely a coincidence of a higher grouping tendency.

Group sizes were equally large in summer on the

range and at the mineral lick. They were slightly smaller during winter than summer, although the seasonal differences were significant for only two of nine radio-collared goats ($p < 0.10$). Mean annual group size ($\bar{x} = 23.9 \pm 24.5$, N = 234 groups) was 7-14 times larger than those reported in other studies ($\bar{x} = 2.5$, Swan Mountains; $\bar{x} = 3.2$, GNP, Chadwick 1977; $\bar{x} = 1.7$, Smith 1977), although Kerr (1965) reported large mean monthly groups sizes of 14 and 18 for the months of March and August, respectively, in west central Alberta.

Conclusions

The Running Rabbit Mountain goat herd was unique compared to other herds. Density was higher than for other well-established native herds, group size was the largest and home range size the smallest. Abundant and closely dispersed food resources are suggested by the high density, large group sizes (Jarman 1974:15) and very small home ranges (Sanderson 1966). In sharp contrast to most studies of Mountain Goats: (1) We observed some billies to be highly social and to frequent mixed sex groups outside of the rut. (2) We observed billies to overlap home ranges extensively with nannies. (3) Kid and male ratios were low and groups sizes high even when compared to other protected National Park herds (Holroyd 1967; Chadwick 1977). (4) Radio-collared individuals were more loyal to fixed and small home ranges, even during the rut, than others have reported (Geist 1964; Rideout 1977). (5) We observed very minor separation of summer-winter ranges (2.2 km maximum distance). Summer range was used during winter thaws and winter range was used during extended summer storms. (6) We observed a very high rate of lick visits ($\bar{x} = 7 \pm 4$ per year for individual goats and more visits likely went unnoticed), but a great deal of individual variability in the number of lick visits, the mean size of the groups, and the relative amounts of association between individual goats. Our data corroborated the findings of others on low associations between individual goats, on peaks in daily activity patterns, and on movements in relation to weather.

The presence of a major lick deposit only 3 km from summer range may have influenced distribution of goats. We suspect the lick location contributed to severe restrictions of goats to only the summer habitat on the southwest half of Running Rabbit Mountain. Also, frequent lick visits may have contributed to the large group sizes.

High goat densities combined with the lack of sport hunting and any major disturbances on Running Rabbit Mountain likely contributed to the strong fidelity to small home ranges, low productivity, and possibly the low male ratio. Other unique features of the herd such as large group sizes, high social tendency in billies, high frequency of lick visits, and severe restriction of summer home ranges were likely related to both high habitat quality and proximity to a major lick. High mean age of animals could be a consequence of a few years of low recruitment. Low fecundity, restricted movements, higher life expectancy, small body size, slower horn and body growth, and a low rate of social interactions are features of "low quality" populations or the maintenance phenotype syndrome of Geist (1971, 1978). The Glacier National Park population fits all features of Geist's low quality model that information is available on, but we have no data on rate of social interactions and too few data on body size and horn growth rates. Harvesting of the GNP goat herd might not necessarily result in higher production. Kuck (1977) observed no compensatory reproduction after harvesting and Chadwick (1977) felt that habitat structure — winter snow relations strongly influenced Mountain Goat population dynamics. More data is needed on the GNP and FNF herds over a wider range in winter conditions. The GNP Mountain Goat herd revealed a wider plasticity in goat movements and sociality to a relatively unique set of environmental conditions than indicated by prior goat studies.

Acknowledgments

We thank Clifford J. Martinka, Robert Arensdorf and Doug Smith for their administrative support, Philip R. Iverson, Dave Panebaker, James Reid, Robert Falkenstein for advice and encouragement, and Steve Nadeau, John Radle, Jeanne Chao and Paul Nader for field assistance. The study was funded by the Federal Highway Administration (Region 8 and the Office of Environmental Design) through Glacier National Park. Douglas Houston and Henry McCutcheon reviewed early versions of the manuscript.

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Received 2 August 1983
Accepted 27 September 1984

Population Characteristics of Elk, *Cervus elaphus,* in Spruce Woods, Southwestern Manitoba

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Hornbeck, Garry E. 1985. Population characteristics of Elk, *Cervus elaphus*, in Spruce Woods, southwestern Manitoba. Canadian Field-Naturalist 99(2): 218–223.

Spruce Woods was censused by aerial survey during three winters (1976-79) in order to determine the size, distribution and structure of the Elk population. Results indicate Elk have increased since the early 1960's when only a few individuals were believed to be present in the area. By 1978-79, the Elk population had increased to about 651 animals, the majority of which were in the Forest Reserve. The density of Elk in the Reserve was 0.60 per km^2 in 1976-77 and 0.91 per km^2 in 1978-79. During the same period, the density of Elk in the adjoining Provincial Park ranged from 0.10 per km^2 to 0.40 per km^2. The male: antlerless ratio averaged 17:100 during the three years of study. Mixed-sex and female (antlerless) aggregations of Elk were larger in the Reserve than in the Park. Male Elk tended to be solitary or to form small groups in both areas. Further increases of Elk are anticipated and the herd is expected to follow the typical eruptive pattern of ungulate growth.

Key Words: Elk, Wapiti, *Cervus elaphus,* population density, sex ratio, and aggregation size.

Early records indicate that Elk (*Cervus elaphus*) were indigenous to Spruce Woods but disappeared from the district by early settlement, about 1887 (Criddle 1929). There is no record of Elk in the area for approximately the next forty years: ". . . except for occasional strays from the north" (Soper 1946, p. 150.).

Elk were not recorded with regularity in Spruce Woods until the early 1960's when a population was re-established. Wrigley (1974) presented the following numbers suggesting that Elk reinvaded Spruce Woods as follows: 1958, 2; 1959, 0; 1960, 15; 1961, 35; 1962, 58; 1963, 63. There were at least 145 Elk in the area by 1969 (Ransom 1969).

Prior to this investigation, therefore, Spruce Woods Elk received only cursory scientific study; there being no systematic attempt to document the herd's status. My study was initiated in January 1977 with field work continuing through July 1978. In addition, a third winter of aerial survey counts (1978-79) was provided (G. Meseman, personal communication). Results pertaining to population size, structure, and distribution, and aggregation size are presented. Observed variations between the two adjoining land jurisdictions; namely, Spruce Woods Forest Reserve and Spruce Woods Provincial Park, are explained in terms of historical and present land uses.

The Study Area

Spruce Woods is a district in southwestern Manitoba (49°55′N, 99°37′W) with a total area of approximately 930 km^2. Included within this area are Spruce Woods Forest Reserve (599 km^2) and the adjoining Spruce Woods Provincial Park (265 km^2) [Figure 1]. The surrounding area is a mixture of private and crown land.

Spruce Woods occurs within the eastern Aspen-Oak and mixed-wood section of the Aspen Parkland (Bird 1961). The Parkland, a transition zone, is characterized by a mosaic of Aspen (*Populus tremuloides*), White Spruce (*Picea glauca*) and grassland. Aspen is the most prevalent species, invading the grasslands as small groves or occurring as irregularly-shaped stands. The mixed-wood section is distinguished by the presence of Spruce and Tamarack (*Larix laricina*).

The topography is rolling to hummocky as a result of the stabilized sand dune formations (Ehrlich et al. 1957). The climate is classified as a humid continental, cool-summer (Critchfield 1974). Distinguishing features of the climate are seasonal temperature extremes and annual variability of precipitation. Snowfall is typically 25 to 40 cm.

Spruce Woods Forest Reserve has been leased to the Canadian Department of National Defense since 1932, and public access to the Reserve has been restricted since that time. Wildfires have occurred frequently and have created a habitat with interspersion of grassland, shrubland, and seral Aspen communities. Grasslands and Aspen communities less than 15 years old comprise approximately 74% of the vegetation mosaic (Kerr et al. 1978).

Spruce Woods Provincial Park was established in 1970 and has a history of settlement and agricultural use. The Park has no recorded history of wildfire and since about 1970, all-season, multiple-use recreational developments have been present. During the years of this study, approximately 18 000 visitors used the

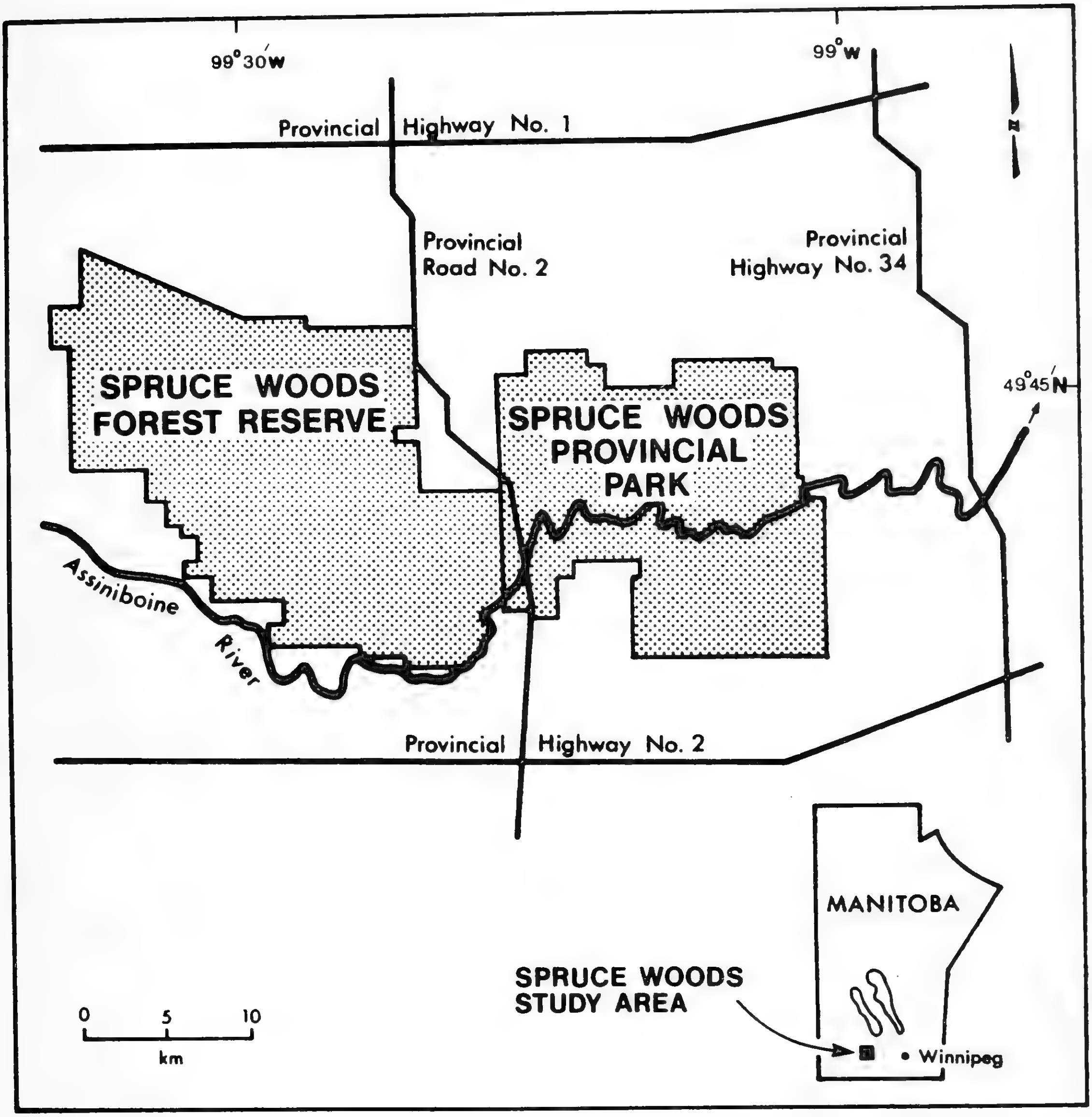

FIGURE 1. Map of Spruce Woods, southwestern Manitoba, showing names and places of importance.

Park annually. The Park is characterized by contiguous stands of Aspen and Aspen-Spruce forest. Grasslands and stabilized openings comprise about 5% of the vegetation cover (Hornbeck 1979).

During the study, the Elk herd was not legally hunted and the area has few, if any, large predators such as Wolves (*Canis lupus*) or Black Bears (*Ursus americanus*).

Methods

The data were collected during three winters (1976-79) of aerial surveys using parallel north-south linear strips covering at least 80% of the study area (Hornbeck 1979). Six fixed-wing aircraft surveys were flown during winter 1976-77); five in the Park and one in the Reserve. During winter 1977-78, two fixed-wing aircraft surveys were flown in the Park and Reserve and a

third survey was flown in the Reserve using a Bell 206 helicopter. In winter 1978-79, a helicopter survey (Bell 206) was flown in the Park and Reserve.

Elk were classified as either antlerless, yearling males (unbranched antler) or adult males (branched antler). The "antlerless" designation includes adult females, yearling females and calves of both sexes because calves and yearling females were not distinguished from adults. Yearling males were considered adult males if they occurred either alone or with adult males. Adult sex identification was considered reliable as surveys were flown before antler drop.

During two winter aerial surveys, 1976-77 and 1977-78, aggregations of Elk were designated as either female (antlerless), male or mixed-sex (having at least one adult of each sex). Student's t test (two-tailed) was used to compare differences in aggregation size when the t test's assumptions were met (Sokal and Rohlf 1969), otherwise the nonparametric Mann-Whitney U test was employed (Siegel 1956). Since there was no significant difference ($P > 0.05$) in size of aggregations between winters 1976-77 and 1977-78, the data in each sex classification were combined for both years.

Results and Discussion

Population Size, Distribution and Structure

The population of Elk in Spruce Woods has increased from a relatively small number believed to be present in the early 1960's to about 651 animals by 1978-79 (Table 1). Furthermore, the largest increase occurred in the Forest Reserve. The density of Elk in 1978-79 was 0.91 per km² in the Reserve compared to 0.40 per km² in the Park. The numbers presented are counts, not estimates, and are, therefore, minimum numbers. It was known that there were Elk in areas outside the Reserve and Park boundaries, and it is well established that aerial surveys of large ungulates tend to underestimate the actual population size (Caughley and Goddard 1972; LeResche and Rausch 1974).

The population structure for the period 1976-79, based on 2535 classified Elk revealed an unbalanced ratio in favour of antlerless Elk. Only a small number of Elk observed in Spruce Woods were male (Table 2). Seventy-four percent of Elk in the Park and 89% of Elk in the Reserve were classified as antlerless. The male:antlerless ratio averaged 17:100 during the three years of study (Table 2).

The male segment of the herd may be underrepresented because males are less conspicuous when censused by aircraft due to the interaction of behavior and habitat. For example, males tend to be solitary, to inhabit areas of extensive cover, and to be more wide ranging (Moran 1973; R.C. Rounds 1976 Selected ecological aspects of Elk and Moose of Riding Mountain National Park, Manitoba. Unpublished report, Parks Canada, Ottawa. 278 pp.; Franklin and Lieb 1979; Hornbeck 1979; Strong 1981). Also, because males tend to be more wide ranging they are likely to be involved in frequent "out-of-range" occurrences and as a result to be heavily poached.

TABLE 1. Number of Elk observed during aerial surveys of Spruce Woods, southwestern Manitoba, 1976–79.

	Spruce Woods Provincial Park (265 km²)					Spruce Woods Forest Reserve (599 km²)				
			Male					Male		
Survey date	Total no.	Antlerless[1]	Yearling	Adult	Elk per km²	Total no.	Antlerless[1]	Yearling	Adult	Elk per km²
1976-77										
17 January	107	82		25	0.40					
4 February	26	5	2	19	0.10					
12 February						358[2]	240	6	12	0.60
15 February	54	38		16	0.20					
28 February	60	46	5	9	0.23					
31 March	38	29	2	7	0.14					
Total/Mean	285	40	2	15	0.22	358	240	6	12	0.60
1977-78										
4 January	64	55	2	7	0.24	370	341	6	23	0.62
20 January						420	350	19	51	0.70
28 February	67	54	6	7	0.25	420	406	1	13	0.70
Total/Mean	131	54	4	7	0.25	1210	366	9	29	0.67
1978-79										
22 January	105	75	17	13	0.40	546	454	56	36	0.91

[1]Includes adult females, yearling females and calves of both sexes.
[2]Includes a group of 100 unclassified Elk observed outside the Forest Reserve boundary.

TABLE 2. Percent classification of Elk observed during aerial surveys of Spruce Woods, southwestern Manitoba, 1976–79.

	Spruce Woods Provincial Park				Spruce Woods Forest Reserve				Sex ratio
			Male				Male		
Winter period	Total no.	Antlerless[1]	Yearling	Adult	Total no.	Antlerless[1]	Yearling	Adult	Males: Antlerless[1]
1976-77	285	70	3	27	258	93	2	5	23:100
1977-78	131	83	6	11	1210	91	2	7	11:100
1978-79	105	71	16	12	546	83	10	7	23:100
All years	521	74	6	20	2014	89	4	7	17:100

[1]Includes adult females, yearling females and calves of both sexes.

Aggregation Size

Aggregations of Elk in Spruce Woods during winter 1976-78 averaged 10.8 individuals (n = 174 groups). Female (antlerless) aggregations ($\bar{x}$ = 14.0, n = 101) were larger ($P < 0.01$) than male aggregations ($\bar{x}$ = 3.3, n = 61). The largest single aggregation was 157 animals. Male aggregations never exceeded 15 animals, with a predominance of singles and small groups. Eighty-five percent of males groups (n = 52) were five or less. Mixed-sex aggregations ($\bar{x}$ = 22.7, n = 12), however, tended to be largest. Rounds (1980) observed similar differences among identical sex classifications of Elk in Riding Mountain National Park, Manitoba, although the size of groups in RMNP were considerably smaller. Studies of North American Elk demonstrate that this pattern is a fundamental characteristic of Elk social organization (Murie 1979) in both western and non-migratory eastern populations.

Comparison of Elk aggregation size between the Forest Reserve and the Provincial Park revealed that female ($\bar{x}$ = 18.5) and mixed-sex aggregations ($\bar{x}$ = 26.7) were larger ($P < 0.05$) in the Reserve than in the Park ($\bar{x}$ = 6.4 and $\bar{x}$ = 17.0, respectively). The size of male aggregations were similar ($P > 0.05$) for the two areas (Reserve: $\bar{x}$ = 3.2; Park: $\bar{x}$ = 3.3) [Figure 2].

Differences in size of female and mixed-sex aggregations between the Park and the Reserve is a predictable response to the different habitats in the two areas. This relationship between group size and habitat is common for ungulates (Hirth 1977). The presence of extensive cover, as found in the Park, make it difficult for animals to remain in contact (Schaller 1967) and promotes opportunistic searching for forage by small groups (Geist 1982). On open ranges, as found in the Reserve, large aggregations afford individuals several advantages; less time spent watching for predators (Bergerud 1974) and less time spent finding forage by watching others (Clutton-Brock 1974). Thus aggregation size reflects an anti-predator strategy as much as a feeding strategy (Geist 1982). Male Elk do not exhibit the same response to changes in habitat. Presumably, there is no evolutionary benefit to male Elk in banding together on open ranges where they would be in competition with females and possibly their own offspring. A dispersal strategy has evolved in males (Geist 1982).

Re-establishment of Elk in Spruce Woods and the subsequent period of increase, particularly in the Forest Reserve, can be directly related to the military's presence. First, by virtue of the military zone, the Reserve has been an effective sanctuary for Elk against direct human disturbance; military activities result, on most occasions, only in indirect disturbance. Geist (1971) theorized that ungulates can learn to avoid disturbances which are "common and localized." Strong (1982, p. 92) supports my assertion and confirms Geist's belief with his observation that: "Elk can habituate to training noise and to the use of specific locales." Second, the military have been responsible for frequent ignition of wildfires in the Reserve. As a result of fire, much of the Reserve is an open forest with large areas in early stages of secondary plant succession, providing an abundance of forage and edge effect.

The Provincial Park, on the other hand, has quite a different history of land use. The Park has been protected from wildfire which has allowed the forest cover to become closed. In addition, the Park has been subjected to intensive year-round recreation which can be expected to result in displacement of Elk. There are numerous studies that have indicated displacement of ungulates from areas of direct human activity (Moran 1973; Dorrance et al. 1975; Schultz and Bailey 1978; Rost and Bailey 1979; Ferguson and Keith 1982).

I believe the military's presence in the Forest Reserve has allowed re-establishment of Elk in that area and, in the absence of large predators or a legal hunting season, has promoted the subsequent increase. I also believe that the lack of seral vegetation and the presence of direct human disturbance have combined to limit the number of Elk in the Provincial Park.

The growth of the Spruce Woods Elk herd can be expected to follow Caughley's (1976) theory of the typical pattern of ungulate growth. According to

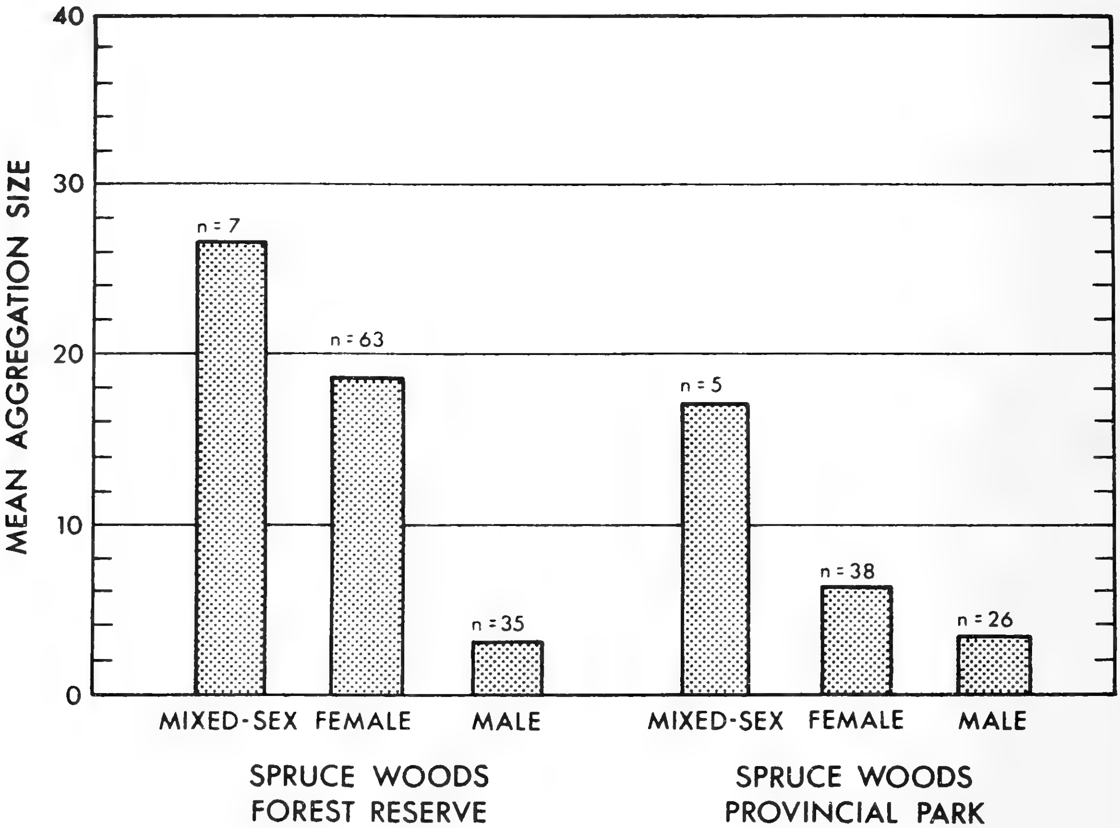

FIGURE 2. Comparison of aggregation size for mixed-sex (at least one adult of each sex), female (adult female, yearling female, and calves of both sexes), and male groups of Elk in Spruce Woods, southwestern Manitoba, winters 1976-78.

Caughley (1976, p. 198): "Whenever an ungulate population is faced with a standing crop of vegetation in excess of that needed for maintenance and replacement of animals, an eruption and crash is the inevitable consequence." Although the Spruce Woods Elk are not "undisturbed", that is, there is some poaching and a limited harvest was instituted in fall 1979, I believe the possibility of an eruption is realistic.

Acknowledgments

I thank Wayne Schick, formerly of the Manitoba Department of Natural Resources, Parks Branch, for obtaining the funds to initiate the study. I am grateful to Gordon Meseman, Dr. M. W. Shoesmith, and others within the Manitoba government, and several members of the Canadian Forces Base, Shilo, who helped solve numerous logistical problems during the field work. Dr. M. B. Bayer of the University of Calgary and Dr. B. L. Horejsi of Western Wildlife Environments Consulting Ltd. made helpful suggestions to early drafts of the manuscript. Dr. R. C. Rounds also provided constructive criticism. Lastly, I dedicate this paper to the late Dr. George M. Van Dyne (1932-1981) who guided me through graduate studies at Colorado State University, Fort Collins.

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Received 14 December 1981
Revised 19 December 1983
Accepted 10 September 1984

Effects of Logging on Bird Populations in British Columbia as Determined by a Modified Point-Count Method

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Breeding bird populations in mature Mountain Hemlock (*Tsuga mertensiana*) and in Engelmann Spruce (*Picea engelmannii*)-Subalpine Fir (*Abies lasiocarpa*) forests and clearcuts were surveyed in 1982. In steep, valley-oriented Mountain Hemlock forests the uncut strip of timber up-slope of the clearcuts supported the same bird communities as did continuous forest extending from below alpine to the valley bottom. In Engelmann Spruce-Subalpine Fir forests, bird communities in unlogged stands between clearcuts were similar to those in large uncut areas. In forests where clearcut logging occurs there is a net loss to mature forest bird populations; however, in residual stands the bird communities continue to exist at similar densities. Also, logging results in a different bird community which occupies the clearcuts. A single-visit modified point-count method was developed for censusing the rugged, heavily forested terrain. The method combines feature of the Finnish line transect and point-count methods. Densities estimated were similar to those obtained in other studies conducted in the northwestern United States and southern British Columbia.

Key Words: Old growth forests, high elevation, birds, clearcut, British Columbia, census methods, point-count, Mountain Hemlock, *Tsuga mertensiana*, Engelmann Spruce, *Picea engelmannii*, Subalpine Fir, *Abies lasiocarpa*.

The British Columbia forest industry is the largest in Canada, employing over 90 000 people and producing 50% of the value of manufactured products in the Province (B.C. Ministry of Forests 1980). In the 1980–81 fiscal year the industry cut 72.6 million m^3 of timber from 187 834 ha. Eighty-three percent of the wood was removed using clearcut methods, primarily from unmanaged stands over 120 years old (B.C. Ministry of Forests 1981). Government plans for intensive forest management, in the face of rapidly diminishing virgin stands, call for increased silvicultural treatment and shorter rotation (B.C. Ministry of Forests 1980). As low elevation areas are cut and as regeneration falls behind harvest rates, higher elevation forests are receiving more harvest pressure.

In 1982, the Canadian Wildlife Service initiated a program to assess the effects of forest cutting on migratory birds. Beginning in high elevation forests, nesting populations were surveyed in stands left uncut adjacent to logged areas. Two null hypothesis were tested: (1) the species mix of birds in uncut stands is the same as before cutting and (2) the density of each species in uncut stands is the same as before cutting.

This paper reports on a method to estimate species density from data collected during a single visit. The method uses a series of singing male listening point-counts which are grouped along a straight line. Density estimates are derived based on detectability functions similar to those used in the Finnish line transect method (Jarvinen and Vaisanen 1975).

Study Areas

Bird populations were sampled in southwestern British Columbia in two biogeoclimatic zones: Mountain Hemlock and Engelmann Spruce-Subalpine Fir (Krajina 1969). Biogeoclimatic zones are delimited primarily on the basis of the combined influences of climate and physiography on the dominant vegetation. Implicit in our use of zones is the assumption that like vegetation reflects similar environmental conditions and hence similar bird populations.

Mountain Hemlock

Censuses of birds were conducted on Mountain Hemlock sites (Figure 1) at Maselpanik Creek (49°04′N, 121°15′W) and Four Mile Creek (49°21′N, 121°22′W). The sites were in steep valleys with slopes between 25° and 42° and aspects facing 90° or 270°. Elevations ranged from 985 m to 1570 m. Dominant trees were Western Hemlock (*Tsuga heterophylla*), Mountain Hemlock (*Tsuga mertensiana*) and Amabilis Fir (*Abies amabilis*). Engelmann Spruce (*Picea engelmannii*), Western Red Cedar (*Thuja plicata*), and Yellow Cedar (*Chamaecyparis nootkatensis*) were also common.

Forested stands were composed of one or two tree strata with total cover from 35% to 80%. Tree height was 20 m to 56 m and age was 90 to 250 plus years (B.C. Forest Service 1975). The shrub layer was composed of young fir, hemlock and cedar trees under 3 m with less than 10% cover. A second layer of primarily False Box (*Pachistima myrsinites*) and *Vaccinium* sp.

under 0.3 m covered less than 10% of the ground. The herbaceous layer was poorly developed with cover values of less than 10%. Snow cover was still up to 80% in the forested valley bottoms while the side slopes were generaly clear.

Clearcuts had been logged from 1972 to 1981 using the high-lead cable method. One clearcut sampled had been burned and planted and the other two were not treated. Regeneration was poor in all clearcuts, with shrub and tree heights generally under 2 m and total cover values less than 10%.

Engelmann Spruce-Subalpine Fir

The Engelmann Spruce-Subalpine Fir study area (49° 19′N, 120° 22′W) was located in the rolling terrain of the Smith and Willis Creek watersheds (Figure 1). Slopes in the area were from 1° to 19° and elevations were between 1450 m and 1850 m.

Forests were over 150 years old with canopy heights from 20 m to 38 m (B.C. Forest Service 1969). Total tree cover ranged from 25% to 65% and was composed of one or two strata. Dominant trees were Engelmann Spruce, Lodgepole Pine (*Pinus contorta*) and Subalpine Fir (*Abies lasiocarpa*). The forest shrub layer was composed primarily of fir trees from 1 m to 5 m with cover values from 5% to 60%. A lower layer of shrubs less than 0.5 m covered 10% to 80% of the ground. Common species in that layer included False Azalea

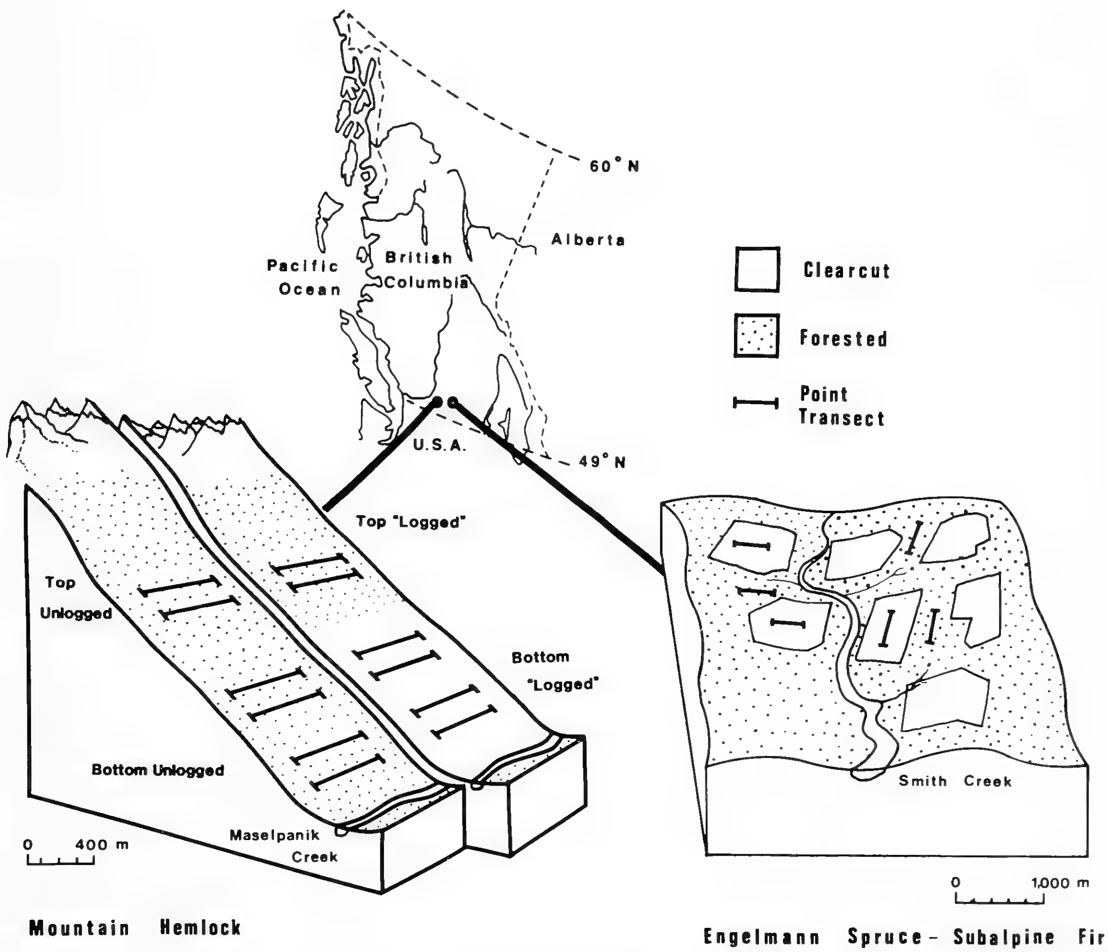

FIGURE 1. Diagrammatic representation of the sampling design used in the two study areas. In Mountain Hemlock forests bird censuses were conducted on paired 'logged' and unlogged plots. One pair is depicted above. 'Logged' plots were composed of a clearcut and a forested component. In Engelmann Spruce-Subalpine Fir forests censuses were conducted on logged, unlogged and control (not shown) areas.

(*Menziesia ferruginea*), Red Twinberry (*Lonicera utahensis*), Labrador Tea (*Ledum glandulosum*), Black Mountain Huckleberry (*Vaccinium membranaceum*) and Kinnikinnick (*Arctostaphylos uva-ursi*). The herbaceous layer was poorly developed with cover values less than 10%.

Logging, using fellerbunchers and rubber-tired grapple-skidders, was conducted from 1972 to 1979. One of 12 clearcuts sampled had been slash burned but none were replanted. Regeneration was poor in all clearcuts, with tree and shrub heights less than 1 m and cover less than 5%.

Experimental Design

Mountain Hemlock

In Mountain Hemlock forests, entire valleys are logged over a period of several years. Logged areas stretch from the valley bottom to as far up the valley wall as economically or technically possible. In this way valleys are stripped of trees except for a band of timber below alpine. In our study areas the distance, with 95% confidence interval, between the valley bottom and the top of the cut was 670 ± 120 m. The band of timber on the upper slope was 664 ± 110 m in width.

Valleys in the process of being logged are mosaics of transversely-oriented cut and uncut bands. Three paired sets of census areas were established in such valleys. Figure 1 shows one of the paired areas. Each paired area had one plot in an uncut transverse band and one plot in a band which was cut at the bottom and forested at the top. Plots within the uncut band are referred to as unlogged plots. The corresponding plot in the cut band is not completely harvested. To avoid confusion we have called that plot the 'logged' plot in quotes. Plots ran from below alpine to the valley bottom. In each pair of plots elevation, aspect and slope were similar.

Five or six bird census lines were placed along the contours in each plot. The top two transects in each plot were in the strip of timber that was or would be left after logging. Care was taken to ensure that this timber was similar in each paired area. The British Columbia Forest Service forest cover maps (1975) and on-site observations were used for that purpose. The remaining transects were placed parallel down the slope. Transects were at least 75 m from forest/clearcut edges or streams. Sampling of plots in a pair was carried out on consecutive days.

Owing to heavy logging pressure we were unable to locate suitable controls in areas untouched by logging activities. One unlogged plot was on the edge of continuous forest which had a different tree species composition while the other two were 37 ha and 96 ha with clearcuts on either side. As a result our comparison in the Mountain Hemlock forest was between 'logged' and unlogged plots.

In order to detect differences in bird populations associated with the strip of forest habitat at the top of the 'logged' plots and to detect the within plot population differences associated with altitude it was necessary to extract subplots (Figure 1). The top and bottom two transects from each plot were identified as follows: (1) Top 'logged' consisted of the two transects in the band of forest above the 'logged' plots; (2) Top unlogged consisted of the top two transects of the unlogged plots; (3) Bottom 'logged' consisted of the bottom two transects in the 'logged' plots; (4) Bottom unloged consisted of the bottom two transects in the unlogged plots. Horn's Ro (Horn 1966) was used to compare the similarities of the bird communities between the various groups. We also tested the subplots for differences in the densities of various species. To ensure adequate numbers for analysis we compared only those species whose total number accounted for the top 50% of the total census observations. The data were analyzed using a Kruskal-Wallis one-way analysis of variance by ranks (Siegel 1956).

Engelmann Spruce-Subalpine Fir

Logging in Engelmann Spruce-Subalpine Fir forests is on a patchwork basis. Clearcut polygons 47.8 ± 6.8 ha in area alternate with interconnected unlogged stands, 413 ± 59 m in narrowest width (± 95% confidence interval). Bird census transects were placed through the middle of 12 logged and 12 unlogged stands. The transects were at least 100 m from any forest/clearcut edge or stream (Figure 1).

Large continuous uncut areas were available so we were able to establish 12 sampling transects which we called controls. British Columbia Forest Service cover maps (1969) and on-site observations were again used to ensure homogeniety of timber type. Horn's Ro was used to compare the similarities of the bird communities in logged, unlogged and control stands.

Methods

We developed a single-visit point-count census which incorporates aspects of the fixed-radius point-count and the Finnish line transect methods (Bond 1975, Jarvinen and Vaisanen 1975). Based on assumptions used in transect sampling, Jarvinen (1978) demonstrated how breeding bird densities could be obtained from Swedish point-count data. Following that lead we developed our method which is suitable for sampling large forested areas in British Columbia where steep terrain and dense vegetation often make travel and bird observation difficult.

The basic sampling unit was a series of four listening points 100 m apart along a straight line. Series

were placed a minimum of 100 m apart. Singing males only were counted at each listening point for five minutes following a one minute wait. Singing males only were counted because a very small proportion of the birds were actually seen and these were often ones attracted by our presence. Birds were placed in one of two categories: 20 m or closer to the observer or further away than 20 m. Individuals heard from two or more points were included in the tally of the point to which they were closest.

Censuses were conducted by the same observers from 3–23 June between 0530 and 1130. Sunup was at 0500 ± 3 min during the period. Five or six series (20 or 24 listening points) were sampled each day. Sampling was not conducted in rain nor when the wind exceeded 10 kph.

To determine the density of singing males from the field data, a relationship between the probability of detection and estimated density was derived. For example, suppose an observer stands for a fixed length of time at a point and records all individuals she hears of a particular species. In addition she records whether each is inside or outside a circle of radius R measured horizontally from the observer. We will call the area within the distance R of the observer the main disk. Further, suppose the procedure is repeated n times at different locations in similar habitat.

Let:

x = horizontal distance of a bird from the observer
n = number of sampling points
$L(x)$ = detectability functions i.e. the probability of hearing the bird at distance x away (assumed to depend only on the horizontal distance from the observer).
g = density (birds per unit area).

Then the expected number of birds detected per unit area at a distance x from the observer is $f(x) = gL(x)$. Further, the expected number of birds detected in all locations between x_1 and x_2 units from the observer is

$$N(x_1,x_2) = \int_{x_1}^{x_2} ngL(x)2\pi x dx$$

$$= 2\pi ng\int_{x_1}^{x_2} xL(x)dx \qquad (1)$$

Further if p is the proportion of birds seen within the main disk, then

$$p = N(0,R)/N(0,\infty) \qquad (2)$$

By integrating (1) to find N and then substituting the result into (2), we are then able to solve for the density, g.

In practice, L(x) is difficult to determine and varies greatly depending on the habitat, observer, weather, etc. In this section we discuss four specific forms for L(x), each depending on one parameter k, and derive density estimates. Each form assumes: (a) $L(O) = 1$, (b) L(x) monotonically decreases as x increases, (c) L(x) does not vary from one sampling area to another and (d) L(x) depends only on the horizontal distance from the observer. Assumption (a) is open to some criticism since it may be possible to miss birds even though they are right overhead; (b) is reasonable since the probability of detecting most species of birds should decrease as distance from the observer increases; (c) is reasonable if the habitat is homogeneous and the weather and observers are consistent; and (d) is not strictly true since vertical height relative to the observer may influence detection.

In each of the models in Table 1 we can find $N(x_1,x_2)$ by substituting L(x) into equation (1) and performing the required integration. The next step is to compute p given in equation (2) and then to solve for the bird density g. Table 2 gives the estimates of g as well as the parameter value k.

Table 3 compares the models relative to the fixed disk method where we assume everything is heard inside the main disk but ignore observations outside.

TABLE 1. Four detectability models considered in the calculation of forest bird population densities in British Columbia.

Model	Detectability function, L(x)		Expected numbers seen, $N(x_1,x_2)$
Linear	$1 - kx$ 0	for $x <= 1/k$ for $x > 1/k$	$\pi ng\left[x_2^2 - x_1^2 - 2k(x_2^3 - x_1^3)/3\right]$
Negative exponential	e^{-kx}		$2\pi ngk^{-2}\left[kx_1e^{-kx} - kx_2e^{-kx} + e^{-kx} - e^{-kx}\right]$
Normal	$.e^{-kx}$		$\pi ng\,(e^{-kx} - e^{-kx})$
Quadratic[a]	$1 - kx^2$ 0	for $0 <= x <= k^{-1/2}$ for $x > k^{-1/2}$	$\pi ng\left[(x_2^2 - x_1^2) - k(x_2^4 - x_1^4)\right]$

[a] Jarvinen and Vaisanen (1975) do not consider the quadratic model for variable width line transect surveys.

TABLE 2. Parameter values (k) and estimates of the density (g) for four detectability models considered in the calculation of forest bird population densities in British Columbia.

Model	Parameter (k)	Density (g)
Linear[a]	$R^{-1}(0.5 + \cos\left[\frac{\cos^{-1}(1-2p) - 2}{3}\right])$	$3(0.5 + \cos\left[\frac{\cos^{-1}(1-2p) - 2\pi}{3}\right])^2 N/\pi n R^2$
Negative exponential[b]	$p = 1 - e^{-kR}(1 + kR)$	$Nk^2/2\pi n$
Normal	$-R^{-2}\ln(1-p)$	$-(N \ln(1-p))/R^2\pi n$
Quadratic[a]	$(1 - \sqrt{1-p})/R^2$	$2N(1-p)/\pi n R^2$

[a]For the linear and quadratic models, solving for k involves a cubic and quartic equation, respectively, yielding multiple solutions, Selby (1967). In each case only one solution gives a value for p between 0 and 1, i.e. is valid.
[b]For the negative exponential model, the solution for k cannot be found in closed form and hence Newton's approximation was used.

In this case the estimated density is

$$g = Np/n\pi R^2$$

The quadratic model gives the smallest estimate. The normal and linear give slightly larger estimates and the negative exponential is much larger than the others. In our study 19% of the total bird observations were made in the main disk. This is similar to the 20% recorded by Jarvinen and Vaisanen (1975) in the 25 m main belts of their transects. From Table 3 ($p = 0.2$) we see that our density estimates are from 6% to 70% higher than with the fixed disk method, depending upon which model is used.

In Finland where a large variety of birds are censused over a wide range of habitat types the linear model is used (Jarvinen and Vaisanen 1975). Scoullar (1980) censused bird populations in British Columbia coastal Western Hemlock forest which grades into Mountain Hemlock forest at higher elevations. He observed that bird songs carried as well in the forest as in open air up to 50 m. He also showed that the maximum distances that 10 species, for which he had data, could be heard in open air varied between 150 m and 700 m. From this we concluded that any model was suspect which showed maximum detectability, for 99% of the birds, to be less than 50 m for a significant number of birds. The quadratic and linear models gave detectability distances of 50 m or less for 50% and 35% of the species respectively. Conversely, the percentages were only 12 for the normal and 9 for the negative exponential.

Using Scoullar's (1980) data we were able to approximate the maximum distance that several species could be heard in the forest. This we compared with the sound extinction distance for four species predicted by our models (Table 4). The normal model showed the least and the negative exponential the most difference.

Although the two tests we used were not conclusive, the indication is that the normal model most closely approximates actual bird detectability and hence density. O'Meara (1981) working in Florida Slash Pine (*Pinus elliottii*) forests compared the Finnish line transect method with spot mapping and found the normal model gave more accurate estimates than did the linear and negative exponential. He did not test the quadratic model.

TABLE 3. Increases in density estimates resulting from the models relative to that obtained by assuming perfect detectability within the main disk and ignoring observations outside.

	Models			
p[a]	Linear	Normal	Negative exponential	Quadratic
0.1	1.15	1.05	1.41	1.03
0.2	1.24	1.12	1.70	1.06
0.3	1.32	1.19	2.01	1.09
0.4	1.41	1.28	2.37	1.13
0.5	1.50	1.39	2.82	1.17
0.6	1.61	1.53	3.41	1.23
0.7	1.74	1.72	4.25	1.29
0.8	1.91	2.01	5.60	1.38
0.9	2.16	2.56	8.41	1.52

[a]p is the proportion of birds seen within the main disk.

Results

Mountain Hemlock

There was no significant difference in total bird density and species composition within the three 'logged' plots nor within the three unlogged plots. Consequently data were combined for further analysis. The total density of singing males in all 'logged' plots was 770/100 ha (24 species) versus 1672/100 ha (24 species) in unlogged plots ($P < 0.01$ Kruskall-Wallis ANOVA). Despite the difference in density, Horn's Ro was quite high (0.84) between 'logged' and

TABLE 4. The maximum distances at which birds can be heard in the forest as predicted by Scoullar (1980 and personal communication) and by the four models.

	Maximum distance (m)				
Species	Scoullar[a]	Normal[b]	Negative[b] exponential	Linear[b]	Quadratic[b]
Chestnut-backed Chickadee	75	77	92	58	53
Red-breasted Nuthatch	138	208	287	161	137
Winter Wren	100	102	128	77	68
Varied Thrush	175	130	170	99	86
Total difference, Scoullar minus model		+29	+189	-93	-144

[a]Scoullar's maximum distance in the forest = 50 m + ¼ (maximum distance in air – 50 m).
[b]The distance at which 99 percent of the birds could be heard was used because of the asymptotic nature of the normal and negative exponential models.

TABLE 5. Singing males/100 ha in the top two and bottom two transects of three 'logged' and three unlogged plots in Mountain Hemlock forests, British Columbia. See Figure 1 for a description of 'logged' and unlogged plots.

Species	Top 'logged'	Top unlogged	Bottom 'logged'	Bottom unlogged
Merlin, *Falco columbarius*	+[a]			
Blue Grouse, *Dendragapus obscurus*	15.95	5.32	47.85	26.58
Rufous Hummingbird, *Selasphorus rufus*				28.09
Red-breasted Sapsucker, *Sphyrapicus ruber*	+		+	+
Northern Flicker, *Colaptes auratus*		72.85		
Olive-sided Flycatcher, *Contopus borealis*[b]		+		+
Say's Phoebe, *Sayornis saya*				36.43
Gray Jay, *Perisoreus canadensis*[c]	12.61	8.41	8.41	+
Common Raven, *Corvus corax*[c]				+
Chestnut-backed Chickadee, *Parus rufescens*	30.85	102.84		61.70
Red-breasted Nuthatch, *Sitta canadensis*	7.06	5.64		1.41
Brown Creeper, *Certhia americana*	67.22	40.33		67.22
Winter Wren, *Troglodytes troglodytes*	135.94	124.11	41.37	94.56
Golden-crowned Kinglet, *Regulus satrapa*	599.83	524.85	49.99	624.83
Hermit Thrush, *Catharus guttatus*	18.57	46.42	3.09	21.66
American Robin, *Turdus migratorius*		25.65	34.20	8.55
Varied Thrush, *Ixoreus naevius*	36.13	108.38	3.61	108.38
Black-throated Gray Warbler, *Dendroica nigrescens*	3.32			
Townsend's Warbler, *D. townsendi*	448.09	497.87		315.32
MacGillivray's Warbler, *Oporornis tolmiei*		6.05	42.32	6.05
Wilson's Warbler, *Wilsonia pusilla*		+		+
White-crowned Sparrow, *Zonotrichia leucophrys*			+	
Dark-eyed Junco, *Junco hyemalis*	5.17	15.52	82.76	
Purple Finch, *Carpodacus purpureus*		22.98		
Pine Siskin, *Carduelis pinus*				16.94
American Goldfinch, *C. tristis*	55.67			
Total Density	1436.41	1607.22	313.60	1417.72
Shannon-Weaver (H')	1.60	1.88	1.90	1.78
Total Species[d]	15	17	11	18

[a]Present but in insufficient numbers to calculate density.
[b]Although a common species on the forest edge, no observations were made in the main disk thus making density estimates impossible.
[c]Nesting was completed prior to census commencements.
[d]Five additional species were present but not in the subplots. Vaux's swift (*Chaetura vauxi*) and Bushtit (*Psaltriparus minimus*) were in the unlogged plots. Orange-crowned Warbler (*Vermivora celata*), Yellow Warbler (*Dendroica petechia*) and Yellow-rumped Warbler (*D. coronata*) were in the clearcut portion of the 'logged' plots.

unlogged plots. This was probably due to the presence of forest in the higher elevations of the 'logged' plots (Figure 1).

More information on the effects of logging can be gained by examining the subplots (Table 5). Bird densities in the bottom 'logged' subplots were significantly lower than in the top 'logged', top unlogged and bottom unlogged subplots ($P < 0.01$ Kruskall-Wallis ANOVA). There was little similarity between the bottom 'logged' and the other three subplots as indicated by Horn's Ro (Table 6). On the other hand all of the forested subplots; top 'logged', top unlogged and bottom unlogged, were similar in terms of density, species number, diversity (Shannon and Weaver 1949) and as measured by Horn's Ro (Tables 5,6). That suggests that the bird population, in the main body of the forest away from streams and edges, is not affected by relative position on the valley wall, nor does the restricted area of the forested habitat at the top of the cut change the community.

Of the individual species analyzed for distributional differences only the Varied Thrush had significant distributional tendencies among the three forested subplots (Table 5). The bird showed a lower density in the top 'logged' subplots ($P < 0.01$ Kruskall-Wallis ANOVA).

As expected some species that generally nest and forage in more open habitats such as Blue Grouse, MacGillivray's Warbler and Dark-eyed Junco seemed to prefer the bottom 'logged' subplots (Table 5). Likewise, some species such as Chestnut-backed Chickadee, Brown Creeper and Townsend's Warbler were found only in forested subplots (Jewett et al. 1953).

Engelmann Spruce-Subalpine Fir

Bird populations in unlogged stands and controls were strikingly similar (Table 7). Total bird density, species number and diversity (Shannon and Weaver 1949) were essentially the same. As a measure of similarity Horn's Ro equaled 0.85. Although we intentionally censused away from forest/clearcut edges, there was an indication (not statistically significant) that the unlogged stands contained higher densities of birds which utilize edges and openings such as Northern Flicker, Winter Wren and American Robin. Similarly the control stands contained higher densities of forest oriented birds such as Boreal Chickadee, Brown Creeper and Townsend's Warbler.

As expected, the bird population of the clearcuts was significantly different from that of unlogged and control stands ($P < 0.01$ Kruskall-Wallis ANOVA). Horn's Ro index of similarity was 0.19 with the unlogged stands and 0.18 with the controls. Interestingly, over half of the species which appeared in the clearcuts were in such limited numbers that density estimates were not possible (Table 7).

TABLE 6. Horn's Ro (Horn 1966) index of similarity of bird populations in subplots in the Mountain Hemlock forest, British Columbia.

	Horn's Ro			
Subplots	Top 'logged'	Top unlogged	Bottom 'logged'	Bottom unlogged
Top 'logged'	1.00			
Top unlogged	0.91	1.00		
Bottom 'logged'	0.44	0.49	1.00	
Bottom unlogged	0.92	0.91	0.46	1.00

Discussion

In the course of censusing forest bird populations a single-visit point-count method was developed. The method was used to sample a relatively large number of forest stands during the short breeding season. The main advantages of the method include: (1) observers must determine only one distance, i.e. all birds heard are counted as either closer or further than 20 m in any direction from the observer; (2) listening from points reduces bird disturbance and eliminates the need to walk and count at the same time (Reynolds et al. 1980); (3) the method is suited for single visit sampling as is done in Finland; (4) point sampling is compatible with the concurrent collection of habitat data and (5) point samples may be combined in any number of ways thus simplifying stratification and subsampling.

Some of the disadvantages of the method are the same as those of the Finnish method. For example, the density of conspicuous species will probably be overestimated. However, for comparisons within a species there is not a problem (Shields 1979). Another disadvantage is that less area per unit of time is sampled than with the line transect method.

Testing is required to determine how the method compares with the spot-mapping method (Williams 1936) and the variable circular-plot method (Reynolds et al. 1980) in terms of accuracy, precision and cost-effectiveness. Testing by O'Meara (1981) concluded that with the normal model the Finnish transect method gave similar density estimates to Emlen's (1971) variable-width transect method. The Finnish method was also found to be more precise and efficient. Both methods resulted in density estimates that were smaller than those calculated from spot-mapping.

There are no quantitative studies of bird populations in Mountain Hemlock forests in British Columbia with which to compare our data. Wiens and Nussbaum (1975) censused birds in a mature forest stand in west central Oregon at 1422 m. The dominant tree species were Mountain Hemlock, Amabilis Fir and

TABLE 7. Singing males/100 ha in Engelmann Spruce-Subalpine Fir forests in the Willis and Smith Creek watersheds, British Columbia.

Species	Logged	Unlogged	Control
Killdeer, *Charadrius vociferus*	+[a]		
Hairy Woodpecker, *Picoides villosus*	+		
Three-toed Woodpecker, *P. tridactylus*		+	
Northern Flicker, *Colaptes auratus*		18.21	
Olive-sided Flycatcher, *Contopus borealis*[b]	+	+	
Gray Jay, *Perisoreus canadensis*[c]	4.20	25.22	31.52
Clark's Nutcracker, *Nucifraga columbiana*[c]		+	+
Common Raven, *Corvus corax*[c]			+
Mountain Chickadee, *Parus gambeli*		35.48	35.48
Boreal Chickadee, *P. hudsonicus*			19.08
Red-breasted Nuthatch, *Sitta canadensis*		2.82	5.64
Pygmy Nuthatch, *S. pygmaea*		+	
Brown Creeper, *Certhia americana*			6.72
Winter Wren, *Troglodytes troglodytes*		38.42	5.91
Golden-crowned Kinglet, *Regulus satrapa*		112.47	137.46
Ruby-crowned Kinglet, *R. calendula*		56.87	31.84
Mountain Bluebird, *Sialia currucoides*	57.46		
Hermit Thrush, *Catharus guttatus*		44.87	30.95
American Robin, *Turdus migratorius*	25.65	8.55	
Varied Thrush, *Ixoreus naevius*		3.61	5.42
Yellow-rumped Warbler, *Dendroica coronata*		26.98	48.56
Black-throated Gray Warbler, *D. nigrescens*[d]		8.30	9.96
Townsend's Warbler, *D. townsendi*		24.89	58.09
Wilson's Warbler, *Wilsonia pusilla*	+		
Black-headed Grosbeak, *Pheucticus melanocephalus*		11.49	
Savannah Sparrow, *Passerculus sandwichensis*	38.16		
Lincoln's Sparrow, *Melospiza lincolnii*	+		
Golden-crowned Sparrow, *Zonotrichia atricapilla*	+		
White-throated Sparrow, *Z. leucophrys*	+		
Dark-eyed Junco, *Junco hyemalis*	90.52	18.10	12.93
Pine Grosbeak, *Pinicola enucleator*			+
Purple Finch, *Carpodacus purpureus*	11.49		22.98
Red Crossbill, *Loxia curvirostra*		11.49	11.49
White-winged Crossbill, *L. leucoptera*	+		+
Pine Siskin, *Carduelis pinus*		8.47	
Evening Grosbeak, *Coccothraustes vespertinus*	3.75	3.70	11.10
Total density	231.18	459.94	485.13
Shannon-Weaver (H')	1.54	2.49	2.40
Total species	15	22	21

[a]Present but in insufficient numbers to calculate density.
[b]Although a common species of the forest edge, no observations were made in the main disk thus making density estimates impossible.
[c]Nesting was completed prior to census commencement.
[d]The birds may have been Townsend's Warblers, which have a similar song.

Nobel Fir (*Abies procera*). They recorded only 13 breeding species with a total population density of 1229 individuals/100 ha. Horvath (1963) working 35 km NNW of Maselpanik Creek in mature coastal Douglas Fir (*Pseudotsuga menziesii*) forest between 49 m and 216 m observed 32 breeding species with a total population density of 2664 individuals/100 ha. In unlogged stands we estimated 25 species and 1678 singing males/100 ha.

Our inability to find suitable controls in the Mountain Hemlock forests forced us to forego definitive conclusions concerning the two null hypothesis. Bird populations in 'logged' stands were half those of unlogged stands, however, the total species count was similar. On examination of the subplots, the major cause of the reduction in bird numbers in the 'logged' stand was the reduction of the forest bird component and the lack of a large number of individuals utilizing

clearcuts. Bird populations in the residual band of timber above clearcuts were similar to those in the unlogged stands, indicating that the residuals are able to maintain bird communities albeit at lower total population levels (Tables 5,6).

Erskine (1977) summarized data from five forest bird studies in the southern interior of British Columbia, Idaho and western Montana. Dominant tree species were Engelmann Spruce, Subalpine Fir, Lodgepole Pine and Douglas Fir. The mean density was 500 males/100 ha which is similar to densities we recorded of 460 males/100 ha in unlogged and 485 males/100 ha in control stands (Table 7). The breeding avifauna of spruce-fir forests in the Rocky Mountains of the United States is remarkably consistent (Smith 1980). That consistency appears to carry into Canada. Our forest bird densities were similar to those summarized by Smith, and all 10 of the bird species that she reported to be most common were observed in our surveys.

We accepted the two null hypothesis concerning bird populations in the Engelmann Spruce-Subalpine Fir forests. Bird populations in the unlogged stands between clearcuts were the same as those in the controls, as measured by density, diversity and total species (Table 7). Horn's Ro for unlogged and control stand was high (0.85). Four species occurred only in the controls and further work is required to determine whether unlogged stands are able to support breeding populations of those species. Five species occurred only in the unlogged stands suggesting that some of them may be nesting in those stands because of proximity to clearcuts. More detailed work is also necessary to test that hypothesis. The addition of clearcuts to the forest introduces a new bird community which has little in common with unlogged or control stands. Horn's Ro was 0.19 and 0.18 respectively and eight species appeared only in the clearcuts.

Thus it appears that clearcutting has two effects on the bird populations in spruce-fir forests. First, forest bird populations are reduced in proportion to the amount of habitat removed and the displaced birds represent a net loss to the breeding populations. This is confirmed by the similarity between the controls and unlogged stands in terms of density, species number, diversity and similarity. In addition clearcutting adds a second bird community which utilizes the open clearcuts.

Acknowledgments

We express our gratitude to Kathleen Fry and Pamela Whitehead, for conducting the singing bird counts. G. and F. Logging in Hope, British Columbia and Weyerhaeuser Canada in Princeton, British Columbia, provided valuable information and access to study areas. Donald Flook, Phillip Whitehead, William Mannan and Anthony Erskine reviewed the manuscript and suggested many improvements. Susan Garnham typed the numerous drafts of the manuscript and Anne Hetherington prepared Figure 1.

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Received 20 December 1983
Accepted 6 September 1984

Movement Patterns of a Lone Wolf, *Canis lupus,* in Unoccupied Wolf Range, Southeastern British Columbia

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Ream, Robert R., Richard B. Harris, Joe Smith, and Diane Boyd. 1985. Movement patterns of a lone Wolf, *Canis lupus,* in unoccupied Wolf range, southeastern British Columbia. Canadian Field-Naturalist 99(2): 234–239.

The movement patterns and habitat use of a lone female Wolf (*Canis lupus*) in extreme southeastern British Columbia were studied by radio-telemetry from April 1979 through July 1980. She was not known to associate with any other Wolves during the course of the study, and no Wolf packs were present on or adjacent to the study area. She occupied a well-defined home range within the North Fork Flathead River drainage. In snow-free months her activity was concentrated in two core areas separated by approximately 40 km, and she was rarely found outside of them. During winter 1979-80 she used only the southern core area and traveled significantly less than in summer. In all seasons she showed strong preference for valley bottoms and avoidance of high elevations; this pattern was accentuated during winter. Her movement patterns were more distinct and predictable than those of lone Wolves living among resident Wolf packs, as reported in the literature.

Key Words: Wolf, *Canis lupus,* home range, movement patterns, core area, British Columbia, Montana.

Wolves have been nearly extirpated from the Rocky Mountains of the western United States and adjacent portions of southeastern British Columbia and southern Alberta. Sporadic Wolf activity in the North Fork Flathead River drainage during the past decade has been reported by Singer (1975) and Day (1981), but breeding and normal pack structure have not been documented. The present Wolf population probably results from dispersers from further north in Alberta and British Columbia and is not self-sustaining (Ream and Mattson 1982).

Lone Wolves are generally considered dispersers (Mech and Frenzel 1971) or older individuals that can no longer keep up with their pack (Jordan et al. 1967). Movements of lone Wolves living in occupied Wolf range have been reported by Mech and Frenzel (1971), Van Ballenberghe et al. (1975), L. N. Carbyn (1980, Ecology and management of Wolves in Riding Mountain National Park, Canadian Wildlife Service report for Parks Canada. 182 pp.), Fuller and Keith (1980) and Fritts and Mech (1981). Lone Wolves usually roam widely and use very large areas, or restrict their movements to areas between established pack territories. In either case, lone Wolves generally avoid established packs.

This paper presents the results from a study of a female lone Wolf living in an area with no established Wolf packs. Preliminary data on this Wolf were presented by Ream and Mattson (1982). Spatial relations with sympatric Coyotes (*Canis latrans*) and food habits of the Wolf were reported by Boyd (1982).

Study Area

The study area was defined by the movements of the Wolf. Most locations were within the North Fork Flathead River drainage of extreme southeastern British Columbia and adjacent Montana (Figure 1, inset). The nearest towns are Fernie, B.C., 72 km north of the international border, and Polebridge, Montana, 29 km to the south. Coniferous forests dominated by lodgepole pine (*Pinus contorta*) cover most of the area, although scattered grassy openings and wet meadows occur on the river floodplain. Extensive clearcuts of areas infested by the mountain pine beetle (*Dendroctonus ponderosae*) are found on the mountain slopes. Elevations range from 1220 m on the river at the Montana border to over 2620 m on the British Columbia-Alberta divide. Potential prey species in the area included Elk (*Cervus elaphus*), White-tailed Deer (*Odocoileus virginianus*) Mule Deer (*O. hemionus*), Moose (*Alces alces*), Beaver (*Castor canadensis*), Snowshoe Hare (*Lepus americanus*), and other small mammals. Elk appeared to be a major food item through the first winter of study. A more thorough description of the study area and land use is given by Boyd (1982).

Methods

The Wolf was captured using a no. 14 Newhouse steel trap. She was anesthetized with a mixture of phencyclidine hydrochloride and promazine hydrochloride using a syringe mounted on a jabstick.

The Wolf was fitted with a radio collar (Telonics,

Inc.) and aerial locations were obtained from fixed wing aircraft (Mech 1974). Ground locations were obtained using hand-held antennas and recorded only if three or more bearings resulted in a polygon of 0.4 km in diameter or less. Mean time interval between successive locations was 3.9 days and was homogeneous throughout all seasons. Plotted locations were investigated on foot to determine her behavior from tracks, scats, kills, etc., and tracks were followed in the direction opposite from her route of travel whenever possible. Locations were plotted on 1:50 000 topographic maps and pertinent habitat features were noted.

Home range size was analyzed using both the minimum convex polygon method (Mohr 1947) and a harmonic mean measure of activity (Dixon and Chapman 1980). A computer program developed at the University of Maryland by K. Orhelein and modified at the University of Idaho (Samuel et al. 1983) was used for the latter analysis[1]. Elevations from within the North Fork Flathead drainage were randomly selected for comparisons with the elevations of the plotted wolf locations following the concept of Marcum and Loftsgaarden (1980). We used nonparametric statistical procedures because the data for distance traveled per day and location elevations were not normally distributed.

Results

The Wolf, a light-grey adult female weighing approximately 36 kg, was captured on 8 April 1979. She was captured and released a second time on 23 April. She was judged to be six to eight years old based on tooth wear, in good health, and on neither occasion did she appear to be pregnant or lactating.

She was located from fixed wing aircraft 105 times and accurately from the ground 18 times, yielding a total of 125 locations including the two captures. She was observed on only two of the flights. On six flights we failed to locate her despite extensive searching, so it is possible that her range was somewhat greater than we recorded. Her radio failed after 20 July 1980 and our attempts to recapture her to replace the collar were unsuccessful.

She was never known to associate with other Wolves during the 16 months of radio-telemetry and subsequent 14 months of field work in the area. Occasional reports of a lone black Wolf in the study area were received, and in September 1981, 14 months after radio-tracking ceased, a single black Wolf was observed by Smith.

The instrumented Wolf occupied a well-defined home range, most of which was within the North Fork Flathead drainage, the remainder being within the Morrisey Creek and Coal Creek drainages. We located her once within Glacier National Park, Montana.

Her home range size was 1144 km^2 (Figure 1), as measured by the minimum convex polygon method. This statistic is misleading because the polygon includes a substantial area of rugged, mountainous terrain that she avoided. The 80% contour (Figure 2) generated by the harmonic mean measure of activity method (Dixon and Chapman 1980, Samuel et al. 1983) reflects her extensive use of the river valley floor, which arcs north and then west from the U.S. border. The enclosed area of 816 km^2 is a more accurate measure of her home range size.

The Wolf's preference for bottomland habitat and avoidance of high elevations was also reflected in the significant difference of the distribution of her location elevations from a set of 125 randomly chosen elevations within the north fork drainage (Kolmogorov-Smirnov two-sample $z = 4.315$, $p < 0.01$).

During the snow-free months, her locations were concentrated within two core areas that were separated by approximately 40 km. She was rarely found very far from these core areas, and rarely found between them. She apparently spent from 3 to 40 days in a core area and then moved rapidly to the other (Figure 3). Her summer mean minimum travel rate was 4.93 km per day, but her daily minimum movements were considerably less than this when she was within a core area, and greater (up to 29 km per day) when moving between core areas.

In contrast, during winter she used only the southern core area of her home range (Figure 2). Between 5 November 1979 and 5 March 1980 she traveled significantly less than during the rest of the year (mean daily movement 1.61 km, Mann-Whitney $U = 212$, $p < 0.001$). Additionally she showed a preference for even lower elevations than during the snow-free months (mean winter elevation 1360 m, mean summer elevation 1523 m; Mann Whitney $U = 308$, $p = 0.02$).

During winter backtracking, she was found to scent-mark her home range by defecating in conspicuous places and by squat-urinating (SQU). In 43 km of backtracking between 23 January and 22 March, we found 21 SQU's (0.49/km) and 17 scats (0.40/km).

During the summer of 1980 she returned to her summer 1979 pattern, using the same two separate core areas. After radio contact was lost, Boyd

[1]The home range area, as measured by percent utilization contours, will vary with differing densities of grid points used to calculate harmonic mean distances. We followed the algorithm suggested by Samuel et al. (1983), resulting in a grid density of 58 × 25, scale 8.5 km/inch for seasonal ranges, and grid density 68 × 30, scale 8.5 km/inch for year-round home range.

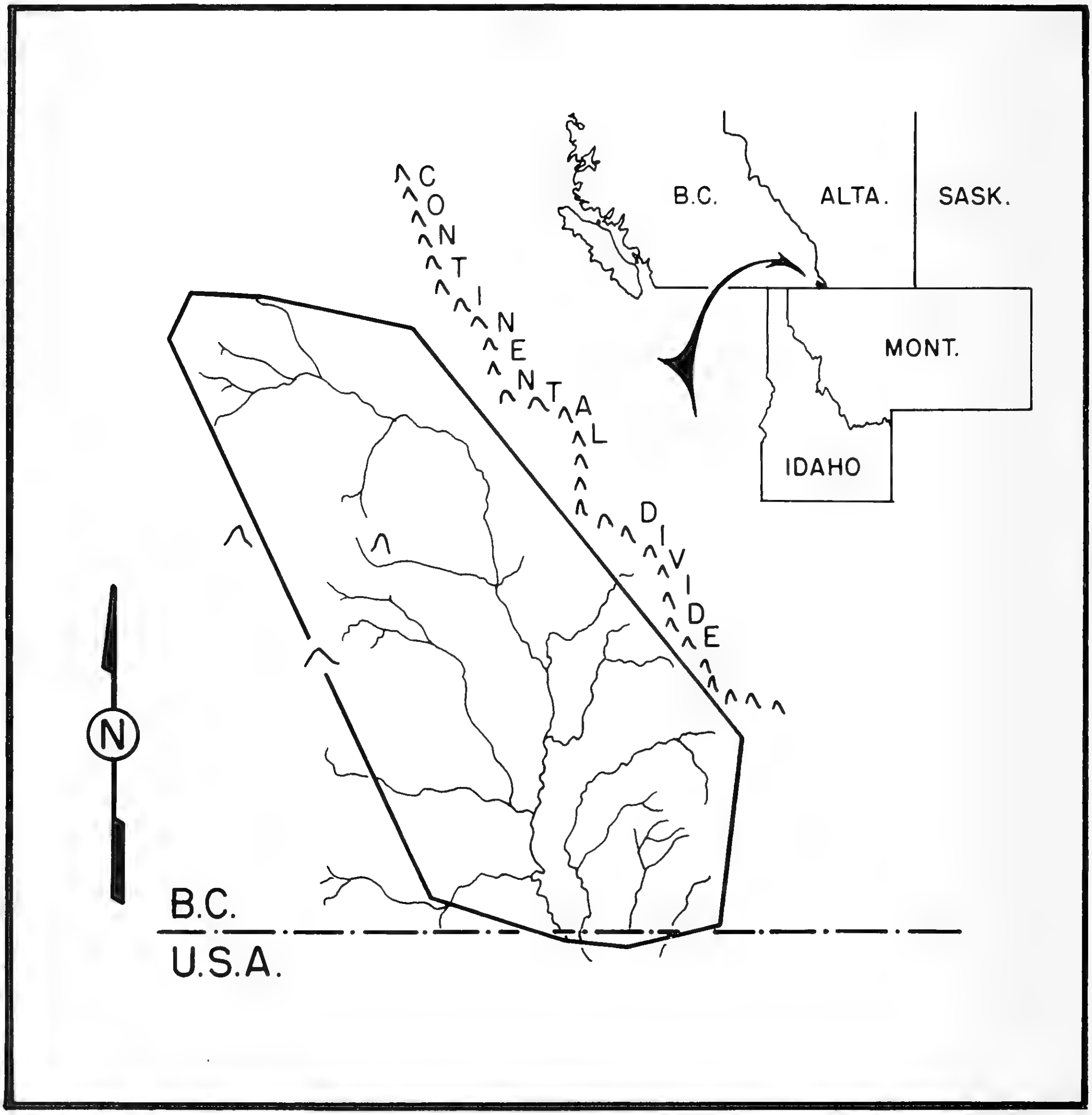

FIGURE 1. The North Fork Flathead river drainage, showing the minimum convex polygon home range for the female lone wolf. Location of study area is shown on inset.

remained in the field through September 1981 and continued to observe tracks of a single Wolf within her home range, which we believe were made by her.

Discussion

This Wolf was the first within the Rocky Mountains to be radio-collared and as such her utilization of mountainous terrain was of interest. She showed strong preference for valley bottoms and avoidance of mountain peaks. The pattern was even more pronounced during the winter months when she used the very lowest portions of her home range exclusively. The compression of her winter home range to a fraction of her year-round home range was similar to Cowan's (1947) findings in Jasper National Park. However, L. N. Carbyn (1974. Wolf predation and

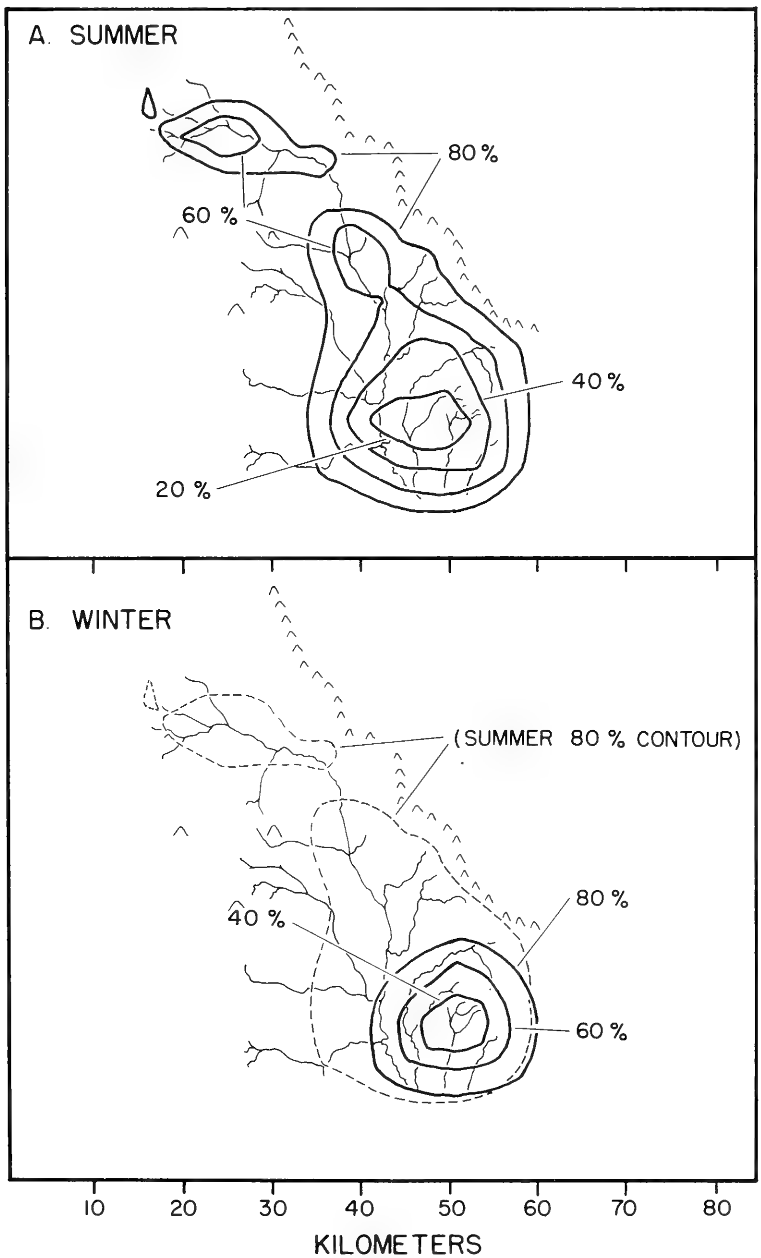

FIGURE 2. The wolf's home range utilization, methods of Dixon and Chapman (1980). The utilization contours represent equal harmonic mean distances from all location. A: Utilization contours from spring, summer and fall locations. Percent of harmonic mean home range area (and actual area) enclosed within contours are: 40% (147 km²), 60% (430 km²), 80% (677 km²). B: Winter utilization contours, with non-winter 80% contour shown by dashed line.

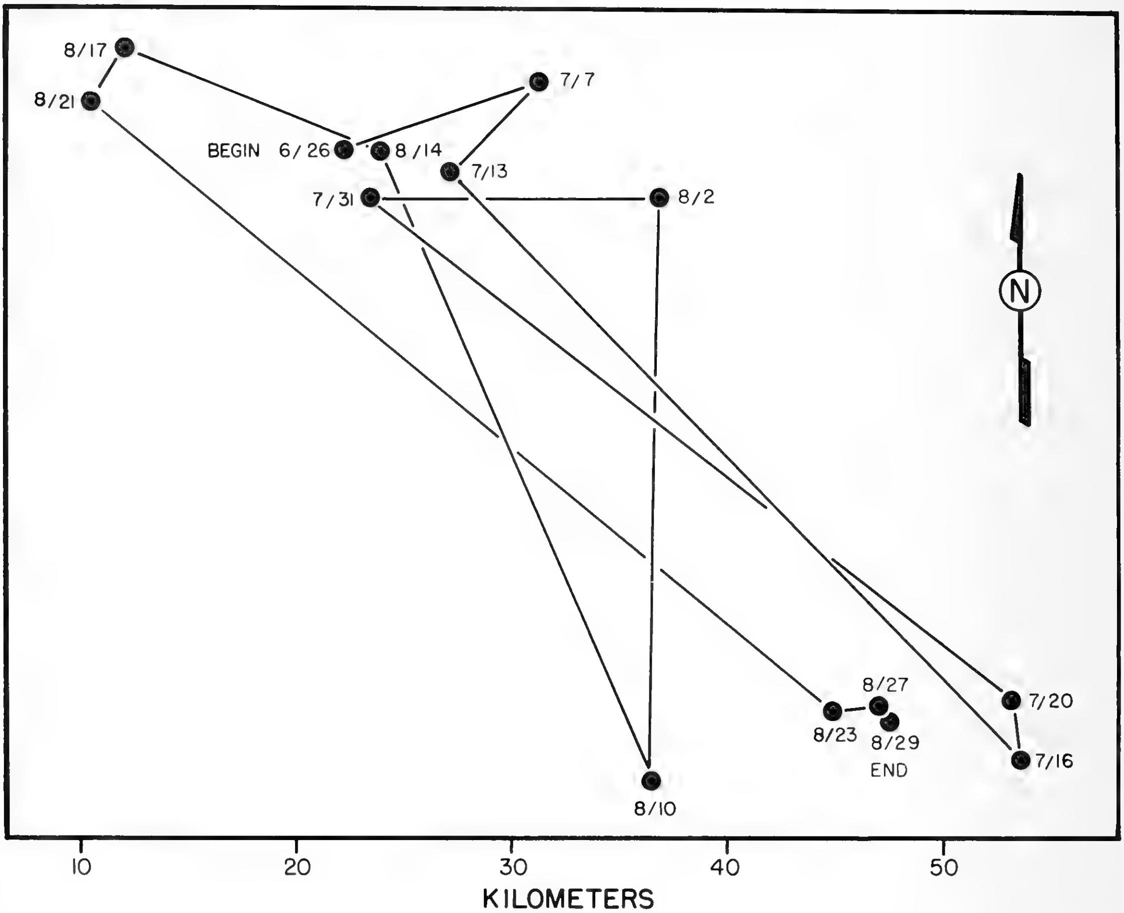

FIGURE 3. Successive locations from 26 June to 29 August 1979, illustrating the wolf's summer pattern of using a southern and a northern core area, but apparently spending very little time between the two.

behavioural interaction with elk and other ungulates in an area of high prey density. Canadian Wildlife Service report for Parks Canada) also working in Jasper, found that Wolves crossed high passes in their travels between valley bottoms. We do not know with certainty the reason for our Wolf's sedentary winter behavior, but it was probably related to high densities of wintering Moose and Elk found in her southern core area (British Columbia Fish and Wildlife Branch, no date. Density of wintering ungulates in the Flathead watershed. Unpublished map). Additionally, winter snow depths may have reduced her movements. Her monthly mean rate of daily travel was negatively correlated with mean monthly snowfall (Spearman $r_s = -0.5522$; $z = -1.83$, $p = 0.03$), calculated as the mean of the Polebridge, Montana and Fernie, B.C., weather station records for 1979–80.

Some behavior patterns of this Wolf were different than those reported for other lone Wolves. In contrast to lone Wolves in other studies (Mech and Frenzel 1971; Van Ballenberghe et al. 1975; Carbyn 1980 [*unpublished report*, see above]; Fuller and Keith 1980; Fritts and Mech 1981), she was not affected by adjacent Wolf packs. Her movements were less nomadic and her fidelity to home range greater than in other published reports. Because we did not have any other wolves radio-tagged prior to or after this study, we can only speculate as to the reasons for her home range fidelity.

One hypothesis is that she represented the sole survivor of a pack that used the drainage during earlier years. If such a pack operated in the usual territorial fashion, her distinct movement pattern may have represented a vestige of this territorial behavior.

An alternative hypothesis is that she dispersed from a more northerly pack, and by establishing a well-defined home range increased the probability that a dispersing male might find her. Her scent-marking behavior is relevant to this hypothesis. Rothman and Mech (1979) documented reduced scent-marking in dispersing lone Wolves. Those Minnesota Wolves were thought to be minimizing evidence of their presence to avoid attacks from nearby packs. Our lone Wolf had no adjacent packs to avoid, and could only have benefited from advertising her presence to a prospective mate. Lone male Wolves have recently been found to scent-mark in a newly established population in Wisconsin (R. Thiel, personal communication). Those wolves are also in an area where Wolf densities are quite low, and attack from packs unlikely.

In July 1982, 10 months after completion of field work, a black male Wolf was accidentally captured and released within the study area by B.C. Fish and Wildlife Branch bear researchers. Shortly afterwards, seven wolf pups at a rendezvous site were observed by the bear researchers and by Boyd near the capture site. We do not know whether the bitch involved was our formerly instrumented animal or a recently dispersed female from further north.

Acknowledgments

Funding for this study came from the U.S. Fish and Wildlife Service, Office of Endangered Species. The British Columbia Ministry of Environment, Fish and Wildlife Branch, Canada Customs and Excise, and the U.S. Customs Service provided special privileges. Logistical support was provided by British Columbia Forest Service, the Flathead National Forest and Glacier National Park. Many field assistants were involved in data collection; special thanks go to U. Mattson, M. Fairchild, S. Gaughan, J. Mariani, and M. Sickles. Several pilots from Strand Aviation, of Kalispell, Montana provided many hours of safe flying. Application of the harmonic home range computer program to the University of Montana DEC-20 system was by J. Glassy. Figures were drawn by D. Williams. Improvements on the manuscript were suggested by B. O'Gara, U. Mattson, and L. Metzgar.

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Received 23 June 1983
Accepted 10 September 1984

Foods of Moose, *Alces alces*, and White-tailed Deer, *Odocoileus virginianus*, on a Burn in Boreal Forest

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Irwin, Larry L. 1985. Foods of Moose, *Alces alces*, and White-tailed Deer, *Odocoileus virginianus* on a burn in boreal forest. Canadian Field-Naturalist 99(2): 240–245.

Food habits were described for Moose (*Alces alces*) and White-tailed Deer (*Odocoileus virginianus*) two years after a wildfire in boreal forest in northeastern Minnesota. Terrestrial diets of Moose were dominated by leaves and twigs of woody species, primarily willows (*Salix* spp.) and Quaking Aspen (*Populus tremuloides*). Deer used a broader variety of foods, but succulent terrestrial species preferred by deer were found in areas that had been logged prior to the fire. Moose appear better able to capitalize upon young forest stages following wildfires because woody plants are abundant and preferred by Moose. Large herbivores may assume a more selective foraging strategy in the presence of high forage supplies, probably resulting in a higher quality diet.

Key Words: *Alces alces,* Moose, *Odocoileus virginianus*, White-tailed Deer, food habits, wildfire.

Many researchers argue for returning natural fire regimes to wilderness areas (Mutch 1970; Wright and Heinselman 1973; Rowe and Scotter 1973; Habeck and Mutch 1973; Loope and Gruell 1973; Mutch 1976). Heinselman (1973) demonstrated the sub-boreal forests in the Boundary Waters Canoe Area (B.W.C.A.) of northern Minnesota have been influenced by wildfire for nearly 10 000 years. To fully understand the role of fire in such wilderness areas or its potential use as a management tool, it is necessasry to learn about responses of native wildlife. A 5900 ha, human-caused wildfire in the B.W.C.A. in May 1971 provided an opportunity to compare foraging responses of White-tailed Deer and Moose in early stages of forest succession following wildfires with food habits studies conducted in unburned areas (Peek et al. 1976; Rogers et al. 1981).

Study Area

The Little Sioux Fire occurred 14-17 May 1971 about 40 km northwest of Ely, Minnesota. Forest conditions were described by Ohmann and Ream (1971), Heinselman (1973), and Books et al. (1971). Fire weather and behavior were described by Sando and Haines (1972) and a description of early, post-fire vegetation production was provided by Ohmann and Grigal (1979). Primary forest types included northern hardwoods and boreal conifers. Prior to the fire much of the area was covered by White Birch (*Betula papyrifera*) and Balsam Fir (*Abies balsamea*), much of which was damaged by Spruce Budworm (*Choristoneura fumiferana*). The most abundant post-fire, understory vegetation included Large-leaf Aster (*Aster macrophyllus*), Fireweed Willow-herb (*Epilobium angustifolium*), Blueberries (*Vaccinium myrtilloides, V. angustifolium*), suckers or sprouts of Quaking Aspen, Beaked Hazelnut (*Corylus cornuta*), Red Maple (*Acer rubrum*), Mountain Maple (*A. spicatum*) and Saskatoon Serviceberry (*Amelanchier alnifolia*).

Methods

Field work was conducted in 1973 from April through December, because ungulate use of the burn was primarily restricted to that time period (Irwin 1975). Regularly-spaced access routes to all areas of the burn were walked to observe deer and Moose and subsequently locate evidence of feeding activity. Food habits were determined using the feeding site technique (Cole 1956; Knowlton 1960). Each feeding site examined was limited to one homogenous vegetation type. If an animal fed in both a conifer type and an adjacent shrubfield, two feeding sites were examined. Feeding sites included locations where Moose or deer were observed feeding, or, more often, where fresh tracks were followed to sites showing fresh feeding activity. Each freshly utilized twig or rooted stem of browse or herbaceous plants, respectively, was considered an instance of use. During summer Moose and deer often stripped leaves from twigs, each occurrence on each twig being considered one instance of use, or bite. Usually no fewer than 50 bites were tallied at each feeding site. Use of aquatic plants was not studied in detail. Percentages of use were calculated using the average aggregate percent technique (Martin et al. 1946). The selectivity index of Alcoze and Zimmerman (1973) was used to designate foods which were preferred in relation to availability. This index is calculated by:

$$E = \frac{U-A}{U+A},$$

TABLE 1. Average aggregate percent use and selectivity indices (E) of major terrestrial foods of Moose on the Little Sioux Burn, Northeastern Minnesota, 1973.

	April-May		June		July		August		September		Oct.-Nov.		December	
	Use	E	Use	E	Use	E	Use	E	Use	E	Use	E	Use	E
Shrubs														
Acer rubrum	tr[a]	0.00	tr	0.00	tr	0.00	7	0.31	15	0.60	23	0.71	22	0.71
Acer spicatum	tr	0.00	14	0.87	15	0.88	13	0.86	3	0.50	4	0.60	0	0.00
Alnus crispa	0	0.00	0	0.00	0	0.00	6	0.13	20	0.40	tr	0.00	2	0.04
Amelanchier alnifolia	0	0.00	0	0.00	2	0.33	0	0.00	tr	0.00	2	0.33	5	0.67
Betula papyrifera	13	0.18	7	-0.11	14	0.23	5	-0.28	10	0.06	6	-0.19	16	0.29
Comptonia peregrina	7	-0.35	0	0.00	0	0.00	0	0.00	0	0.00	tr	-0.66	8	-0.29
Cornus stolonifera	tr	0.00	0	0.00	tr	0.00	tr	0.00	2	-0.18	5	-0.06	3	-0.12
Corylus cornuta	7	-0.16	4	-0.42	2	-0.66	0	0.00	2	-0.66	17	0.21	14	0.24
Diervilla lonicera	4	-0.17	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Populus tremuloides	11	-0.16	20	0.15	18	0.10	2	-0.76	0	0.00	16	0.11	24	0.15
Prunus pennsylvanica	3	-0.68	tr	0.00	0	0.00	20	0.12	17	0.04	2	-0.59	4	-0.30
Prunus virginiana	14	0.25	0	0.00	tr	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Ribes americanum	7	-0.11	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Salix spp.	28	0.93	31	0.94	31	0.94	41	0.95	22	0.91	22	0.91	0	0.00
Total Shrubs	100		80		92		96		91		100		100	
Forbs														
Cornus rugosa	0	0.00	2	-0.12	tr	0.00	0	0.00	8	0.10	0	0.00	0	0.00
Epilobium angustifolium	0	0.00	17	0.71	7	0.56	4	0.31	tr	0.00	0	0.00	0	0.00
Total forbs	0		19		8		4		9		0		0	
Total instances of use		2023		904		2124		1215		1314		4642		2106
Number of feeding sites		17		7		13		7		9		26		8

[a]tr = trace amounts comprising less than 2% of the aggregate.

where U is the aggregate percent use of each species, and A is the associated percent availability. Values vary between +1.0 and –1.0. Although statistical tests are not developed for this index, values of ± 0.60 or greater are considered statistically significant. Availability was summarized using biomass data from Ohmann and Grigal (1979). Plant nomenclature follows Lakela (1965).

Results

Moose Food Habits

A total of 14 368 instances of use by Moose was recorded at 87 feeding sites (Table 1). Twenty-two woody or shrubby species comprised 90–95% of the terrestrial diet of Moose using the burn. Bebb Willow (*Salix bebbiana*), Pussy Willow (*S. discolor*), and Slender Willow (*S. interior*) comprised 25% of the total diet. These willows were most abundant in Jack Pine (*Pinus banksiana*) stands and along roads and trails, where they were highly used. Sandbar Willow (*S. gracilis*), present along streams in the study area, was little used.

Willows, Alien Sweetfern (*Comptonia peregrina*), Currant (*Ribes americanum*), Pin Cherry (*Prunus pennsylvanica*), Choke Cherry (*P. virginiana*), and White Birch formed about 75% of the diet at 17 feeding sites in April and May. However, only willows were preferred, according to the selectivity indices. In June Moose fed extensively in streams and ponds on water milfoil (*Myriophyllum* sp.), pond lillies (*Nuphar variegatum, N. microphyllum*, and others).

In summer 3 339 instances of use were recorded in 20 feeding sites. The only terrestrial herbaceous species important to Moose was Fireweed Willow-herb. Quaking Aspen received high use in early summer and again in late fall. Mountain Maple was most used during summer and Pin Cherry in late summer. White Birch was eaten in fairly constant amounts (5-16%) throughout the study period. Alder (*Alnus crispa*) received relatively high use in Jack Pine and Black Spruce (*Picea mariana*) communities during late August and September. Selectivity indices for summer indicated Moose preferred aspen, willows, Pin Cherry, Mountain Maple, and Fireweed.

Diets were different in autumn, when 6 748 bites were counted in 34 feeding sites. Beaked Hazelnut was relatively unimportant except during November when many observations of Moose and feeding sites were found near the edges of the burn where this species was most abundant. Moose used Red Maple in high amounts in late fall. Observations indicated nearly every current leader of Red Maple had been browsed by December in some areas of the burn. Red Osier Dogwood (*Cornus stolonifera*), present near streams but not abundant within the burn, was browsed during October. Red Maple, willows, Beaked Hazelnut, and Saskatoon Serviceberry were preferred in fall and early winter.

Deer Food Habits

White-tailed Deer fed upon at least 42 species on the burn, as determined from 3 827 instances of use at 52 feeding sites (Table 2). Browse comprised over 50% of the diet except in spring and early summer, when deer used grasses, sedges, Wild Sarsaparilla (*Aralia nudicaulis*), and White Clover (*Trifolium repens*). Most of these species were abundant in disturbed openings along road edges and logged areas of the burn. In June deer also fed in streams and ponds, using Water Milfoil and pond lillies. Deer used a broader variety of foods than Moose, including succulents such as asters, Sweet Peas (*Lathyrus paliestris, L. ochroleucus*), White Clover, Canada Goldenrod (*Solidago canadensis*), and Spotted Snapweed (*Impatiens capensis*). All of these species were abundant in areas logged prior to the fire.

When succulent forbs became desiccated in August, deer browsed leaves of shrubs more often, including Red Maple, White Birch, Pin Cherry, and Common Bush Honeysuckle (*Diervilla lonicera*). They preferred Pin Cherry and Bush Honeysuckle during August and September and Red Maple in all periods.

Discussion

The Little Sioux Fire did not significantly change plant composition in comparison to adjacent unburned communities (Ohmann and Grigal 1979). Thus, diets of deer and Moose were similar to those observed elsewhere in Minnesota (Kohn and Mooty 1971; Peek et al. 1976), Wisconsin (McCaffery et al. 1974), Michigan (Belovsky and Jordan 1978), New Brunswick (Skinner and Telfer 1974), and the Great Lakes Region (Rogers et al. 1981). But deer were more selective of their diets than Moose, which fits theoretical predictions associated with body size (Hanley 1982). However, areas within the Little Sioux Burn that produced herbaceous deer foods were logged before the fire occurred. Also, the flush in increased biomass production of herbs lasted only two years, then declined (Ohmann and Grigal 1979). Thus, Moose seem better adapted to exploit the extensive shrubfields and young tree stands which follow wildfires, and the Moose population rapidly increased (Irwin 1975).

While the available literature indicates the Little Sioux Fire would be expected to benefit Moose (see review by Davis and Franzmann 1979), the mechanism is unclear. Data collected on the Little Sioux Burn by Ohmann and Grigal (1979) indicated that not only was vegetation composition similar to unburned communities, forage quality was not significantly

TABLE 2. Average aggregate percent use and selectivity indices (E) of terrestrial foods of White-tailed Deer on the Little Sioux Burn, Northeastern Minnesota, 1973.

	April-May		June		July		August		September		Oct.-Nov.		December	
	Use	E	Use	E	Use	E	Use	E	Use	E	Use	E	Use	E
Graminoids	36	0.45	3	0.01	0	0.00	0	0.00	0	0.00	5	0.16	0	0.00
Forbs														
Aralia hispida	0	0.00	0	0.00	0	0.00	3	0.02	6	0.06	0	0.00	0	0.00
Aralia nudicaulis	0	0.00	18	0.40	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Aster spp.	tr[a]	0.00	0	0.00	10	0.01	tr	0.00	3	-0.14	0	0.00	0	0.00
Botrychium spp.	10	0.31	tr	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Epilobium angustifolium	0	0.00	tr	0.00	3	0.50	8	0.78	0	0.00	0	0.00	0	0.00
Impatiens capensis	0	0.00	0	0.00	8	0.62	0	0.00	0	0.00	0	0.00	0	0.00
Polygonum cilinode	0	0.00	0	0.00	0	0.00	3	-0.20	11	0.16	0	0.00	0	0.00
Potentilla norvegica	0	0.00	0	0.00	10	-0.11	0	0.00	0	0.00	0	0.00	0	0.00
Solidago canadensis	0	0.00	0	0.00	12	0.24	0	0.00	0	0.00	0	0.00	0	0.00
Trifolium repens	11	0.35	0	0.00	2	0.10	11	0.35	9	0.26	11	0.35	0	0.00
Total Forbs	28		49		57		33		34		13		2	
Shrubs														
Acer rubrum	11	0.50	18	0.60	5	0.15	5	0.15	tr	0.00	49	0.86	40	0.83
Acer spicatum	0	0.00	4	0.60	tr	0.00	0	0.00	4	0.60	0	0.00	2	0.20
Amelanchier alnifolia	0	0.00	0	0.00	8	0.78	tr	0.00	0	0.00	4	0.60	2	0.40
Betula papyrifera	tr	0.00	6	-0.19	4	-0.38	8	-0.05	0	0.00	7	-0.11	0	0.00
Comptonia peregrina	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	23	0.23
Cornus stolonifera	10	0.22	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Corylus cornuta	0	0.00	4	-0.42	0	0.00	tr	0.00	0	0.00	12	0.11	0	0.00
Diervilla lonicera	0	0.00	0	0.00	2	-0.47	20	0.57	36	0.74	0	0.00	0	0.00
Ledum groenlandicum	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	9	0.10
Pinus banksiana	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	4	-0.60	19	-0.10
Populus tremuloides	0	0.00	16	0.03	3	-0.75	0	0.00	0	0.00	tr	0.00	tr	0.00
Prunus pennsylvanica	0	0.00	0	0.00	12	-0.13	16	0.01	20	0.12	0	0.00	0	0.00
Salix spp.	3	0.50	0	0.00	0	0.00	5	0.67	2	0.33	tr	0.00	0	0.00
Total shrubs	36		48		43		67		66		82		98	
Total instances of use		235		492		778		570		490		480		782
Number of feeding sites		9		6		8		8		5		6		10

[a]tr = trace amounts comprising less than 2% of the aggregate.

changed. Foods eaten by Moose on the burn were not significantly distinct from those observed by Peek et al. (1976) in similar unburned (but logged) plant communities elsewhere in northeastern Minnesota. Also, the Moose population increased despite the presence of the roundworm parasite, *Parelaphostrongylus tenuis* (Irwin 1975).

The following hypothesis is proposed to account for the increased moose population. Total nutrient mass was increased following burning and most of the biomass was contained in young trees, tall shrubs, and low shrubs (Ohmann and Grigal 1979), all available to Moose. Habitat selection data from Irwin (1975) indicated Moose were highly selective in summer for Aspen-Birch and Fir-Birch communities which were most productive of biomass. Moose were also most selective of their diets in summer. In the midst of concentrated nutrients and forage supplies, Moose probably could afford to be selective, not only of items to be included in their diets, as Belovsky and Jordan (1978) indicate, but also for which plant parts to include.

Thus, their diets were likely more digestible and they could have subsequently increased the rate of food intake (Hanley 1982). This could have occurred even though nutrient quality per individual plant and species composition were not significantly different from unburned communities. With better overall diets, Moose reproductive performance improved (Irwin 1975), and the population increased. Hobbs and Spowart (1984) made a similar observation for Rocky Mountain Bighorn Sheep (*Ovis canadensis*) feeding within burned communities in Colorado. In their study, burning did not improve nutritional quality of vegetation, but burning did allow sheep to select better diets because nutrients were more concentrated.

This study has other implications in understanding the habitat-population interaction. Since Moose do not use the Little Sioux Burn significantly in winter (Neu et al. 1974), their population increase can probably be attributed to improved summer diets and not winter diets, as traditionally believed. Thus, this study provides additional circumstantial evidence of the value of summer forage in population regulation of ungulates (Julander et al. 1961; Verme 1965; Klein 1965). Also, habitat selection by Moose and deer appears related to optimizing forage intake by keying on food patches with highest quantities of preferred foods, which suggests determinants of seasonal home range selection and food patch selection are basic to population regulation in ungulates. Ultimately, an understanding of this interaction will provide an ability to predict population changes resulting from habitat changes, by linking population-simulation models with models of forage-habitat conditions, as Caughley (1981) suggests.

Acknowledgments

This study was financed by the Minneapolis Big Game Club, the Superior National Forest, and the University of Minnesota Agricultural Experiment Station. The supervision and encouragement of J. M. Peek is appreciated.

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Received 11 August 1983
Accepted 22 October 1984

Thermoregulatory Behaviour in the Northern Water Snake, *Nerodia s. sipedon*, and the Eastern Garter Snake, *Thamnophis s. sirtalis*

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Justy, Gordon M., and Frank F. Mallory. 1985. Thermoregulatory behaviour in the Northern Water Snake, *Nerodia s. sipedon*, and the Eastern Garter Snake, *Thamnophis s. sirtalis*. Canadian Field-Naturalist 99(2): 246–249.

Thermoregulatory behaviour in the morning and afternoon, under light and dark conditions, was studied in the snakes *Thamnophis sirtalis sirtalis* and *Nerodia sipedon sipedon*. Experimental testing in a thermal gradient demonstrated that the mean temperatures and ranges selected in the morning and afternoon by *Thamnophis* were significantly different under conditions of diffuse light, but not under dark conditions. Although significant differences were not found for *Nerodia* when tested under the same conditions, a similar trend was evident. These results may be related to the feeding strategies of these species and the interaction of endogenous circadian rhythms and light.

Key Words: thermoregulation, circadian rhythms, Northern Water Snake, *Nerodia s. sipedon*, Eastern Garter Snake, *Thamnophis s. sirtalis*.

Ectotherms can regulate body temperature to a limited extent by exploiting the microclimatic variations in their environment. Circadian rhythms are also known to be an integral component of behaviour and are often species specific. Recently, ectothermic thermoregulatory activity has been correlated with circadian rhythms implying that this behaviour may be controlled by interaction between environmental stimuli and the endogenous circadian mechanism of a species (Cowgell and Underwood 1979; Kavaliers 1980).

Snakes have been shown to regulate body temperature and select specific ranges of temperature which are assumed to be preferred (Stewart 1965). However, little research has been performed to analyze the interaction of thermoregulatory behaviour and circadian rhythm in this group of vertebrates. Heckrotte (1975) demonstrated that locomotory activity follows a circadian pattern in the Western Plains Garter Snake, *Thamnophis radix hayendi,* when temperature is kept constant. Similarly, Gehrmann (1971) found significant changes in circadian activity in the Blotched Water Snake, *Nerodia erythrogaster transversa,* when kept under a constant 12 hours light — 12 hours dark photoperiod. The periodicity of this activity was found to disappear when the animals were maintained in continuous light conditions.

The present study compares the Northern Water Snake, *Nerodia sipedon sipedon,* and the Eastern Garter Snake, *Thamnophis sirtalis sirtalis,* which are both common in southern Ontario but exploit the resources of different habitats. *Nerodia* is highly aquatic and largely restricted to the immediate vicinity of bodies of fresh water in the region, whereas *Thamnophis* is more terrestrial, often found in fields and grassland habitats (Logier 1965). Observations were recorded in a thermal gradient under different illuminations and times of day to determine (1) if thermoregulatory behaviour was influenced by the interaction of circadian phenomena and light, and (2) if species-specific differences existed.

Methods

Adults of *Thamnophis s. sirtalis* and *Nerodia s. sipedon* were collected during May 1980, from sites on and near the Credit River, Oakville, Ontario. Prior to the experiment, animals were kept in separate 76-litre glass aquaria illuminated by 60-watt incadescent bulbs maintained on a 14 hour light/10 hour dark photoperiod (0700 to 2100 h). Aquaria were lined with newspaper and each was provided with cardboard shelters and water ad libitum. All animals were allowed to acclimate for a minimum of three weeks before being introduced to the experiment.

The thermal gradient used to test the animals was constructed of 1.25 cm plywood and had internal dimensions 100 cm × 25 cm × 25 cm. The top was open and the floor had a false bottom of galvanized steel. The hot end of the gradient was controlled by placing a 0.6-cm coiled copper tube to the underside of the steel floor and running hot water through it from an immersion heat-pump in a 20-l water bath. The cold end of the gradient was maintained by placing a frozen blue pack (50 cm × 20 cm × 25 cm) beneath the bottom just prior to each experiment. An even and continuous horizontal temperature gradient ranging from 12°C to 45°C was established on the steel floor-

ing. The inside of the gradient was lined with plastic sheeting, overlain with newspaper. This lining was changed after each test run, to minimize the pheromonal influences of the previous occupant. A thin piece of newspaper, 0.5 cm in width, was placed around the inside perimeter of the gradient to provide the animals with the tactile sensation of shelter without eliminating the light stimulus. The open top was fitted with a screen mesh and three equally spaced 15-watt bulbs were placed 1 m above the floor of the gradient. A transluscent sheet of plastic was mounted between the bulbs and the screening, resulting in a nearly uniform light regime. No significant radiant heating of the gradient due to the lighting system was observed.

The internal temperature of each animal was measured by a cylindrical "minimitter" transmitter (1.5 cm × 0.8 cm) powered by a 1.5 v battery. The pulses emitted by these transmitters were received by AM radio as short clicks. The frequency of pulses changed with temperature, and, counted over a 20 s time period, provided an accurate estimate of body temperature (± 0.5° C). Transmitters were recalibrated in a water bath weekly, over the entire range of temperatures associated with the gradient, and force fed to the animals one to two days before each test run.

A three-treatment factorial experimental design was used, with each treatment divided into two components as follows: Species (*Thamnophis, Nerodia*); Time (0900, 1300); and illumination (light, dark). Animals were acclimated to the experimental gradient 40 min prior to the 90 min observation period. Three specimens were used in each treatment component and the range and mean temperature selected were calculated and analyzed using a comparison of means test.

Results

The mean internal temperature and range of temperatures selected by each individual were calculated for the 90 min period, from pulses counted at 20 s intervals during each test period. From these data (n = 270/specimen), temperature means and ranges were established for each species under the varying experimental conditions. A Bartlett's test for nonequality indicated that variance between species was significantly different ($x^2 = 6.61$; $P < 0.02$) and therefore comparison using factorial analysis was not possible. However, this difference in variance demonstrated that the behaviour of the two species varied significantly when exposed to the same experimental conditions.

The temperature means and ranges for each species are summarized in Table 1. An analysis of variance performed on the data from each species indicated that significant effects in behaviour were produced in *Thamnophis* but not *Nerodia* (Table 2). The percentage of time that *Thamnophis* spent at each internal temperature during the different treatment combinations are illustrated in Figures 1 and 2. When the experimental chamber was illuminated, *Thamnophis* selected significantly lower mean temperatures with a greater range in the morning, as compared to the afternoon (Figure 1). However, in the absence of light, no significant differences in mean internal temperatures or range selected was established, although the same general trend was evident (Figure 2). A significant interaction was established (Table 2) between the presences of light and the time of day (morning/afternoon). No significant differences were observed for *Nerodia* with respect to mean internal temperature or range (Tables 1 and 2) due to the great variance observed in this species' behaviour. However, the same general trend was present as was found in *Thamnophis*.

Discussion

The data support the conclusion that thermoregulatory behaviour in the Eastern Garter Snake, *Thamnophis s. sirtalis,* is influenced by an interaction between the time of day (morning/afternoon) and the presence of light. Preferred temperature ranges selected in the morning-light and dark treatments and the afternoon-dark treatment were highly variable,

TABLE 1. Mean internal temperatures and ranges (± SEM) selected by *Thamnophis s. sirtalis* and *Nerodia s. sipedon* when exposed to a thermal gradient from 12°C to 45°C (n = 3).

		Morning		Afternoon	
	Species	Light	Dark	Light	Dark
Temperature Range	*Thamnophis*	12.0	11.0	5.7	13.4
	Nerodia	12.8	10.2	5.2	15.8
Mean Internal Temperature	*Thamnophis*	28.3 ± 0.4	24.6 ± 0.5	33.0 ± 0.2	24.5 ± 0.5
	Nerodia	30.4 ± 0.4	32.0 ± 0.4	34.0 ± 0.2	29.5 ± 0.8

TABLE 2. Significant levels (F-ratios) of preferred mean internal temperatures in the snakes, *Thamnophis s. sirtalis* and *Nerodia s. sipedon* when exposed to a thermal gradient ranging from 12°C to 45°C and different environmental stimuli (light/time of day).

		Response	
Species	Treatment	Internal Temperature	Temperature Range
Thamnophis	Light	12.4 ($P < 0.01$)	6.9 ($P < 0.05$)
	Time (morning/afternoon)	13.6 ($P < 0.01$)	2.8 (N.S.)
	Light × Time	0.1 (N.S.)	7.1 ($P < 0.03$)
Nerodia	Light	0.8 (N.S.)	1.7 (N.S.)
	Time (morning/afternoon)	0.4 (N.S.)	0.0 (N.S.)
	Light × Time	1.8 (N.S.)	3.7 (N.S.)

indicating that animals are less discriminatory under these conditions. However, the data from the afternoon-light treatment demonstrate that during these conditions the animals select a specific and narrow temperature range with a mean internal temperature which is significantly greater than that found in other treatments. Although no significant changes in behaviour were found in the Northern Water Snake, *Nerodia s. sipedon,* due to the large variance, a trend similar to that found in *Thamnophis* was evident. *Nerodia* has been observed to be more excitable and less adaptable to captivity (Logier 1965). For this reason a different experimental procedure may be required to establish the thermoregulatory preferences of this species.

Light-temperature interactions effected by circadian rhythms have been associated with behavioural changes in other ectotherms. Heckrotte (1975) observed that *Thamnophis radix* maintained at a constant temperature of 35°C, was less active at high light intensities, than at low light intensities, and had activity peaks in the morning and afternoon. Thermoregulatory behaviour associated with circadian rhythms have also been recorded in lizards (Cowgell and Underwood 1979) and gastropods (Kavaliers 1980).

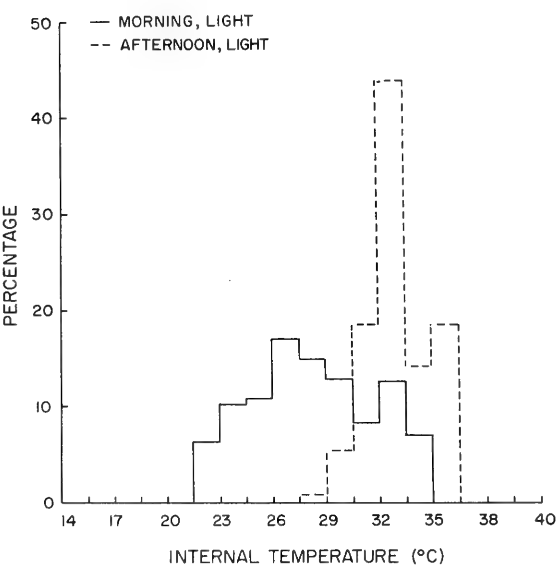

FIGURE 1. Frequencies (%) of internal temperatures (C°) selected by *Thamnophis* during a 90-min experimental period in the morning and afternoon under diffuse lighting conditions (n = 3).

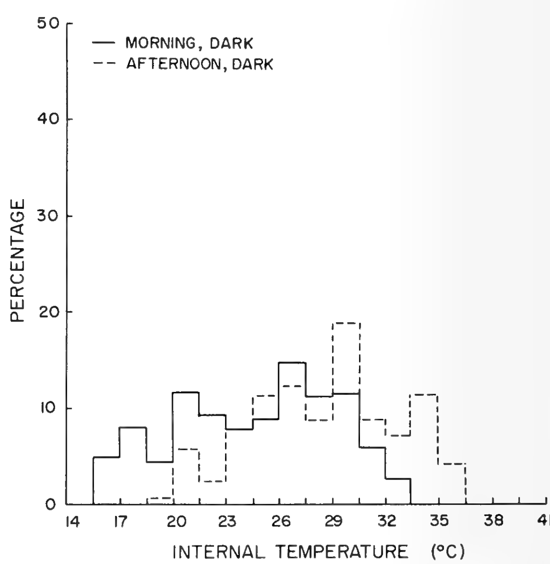

FIGURE 2. Frequencies (%) of internal temperatures (C°) selected by *Thamnophis* during a 90-min experimental period in the morning and afternoon under dark conditions (n = 3).

The reasons for the changes in behaviour found in *Thamnophis* can only be speculated upon at this time. However, it seems reasonable to hypothesize that they represent an important component of the foraging and feeding strategy of this species. Skoczylas (1970) found that the European Grass Snake, *Natrix natrix,* preferred higher temperatures after eating. Increased enzyme activity rates, important for digestion and assimilation have been associated with moderate temperature elevations in most biological systems (Hoar 1966; Aleksiuk 1971). A diurnal species like *Thamnophis* starting to forage at dawn in an environment with a reasonable supply of prey items, would have an increased probability of capturing a food item as the day unflolds due to the time spent in this activity. Foraging success would be enhanced by the increased activity associated with the morning, as found in this study. It is not unreasonable to suggest that by the afternoon, most individuals would have been successful and that selection would then favour a change in activity which would augment digestion and assimilation. Higher temperatures and reduced locomotory activities, as found in this study, would have this affect, as enzyme systems would become more efficient and the body's energies could be redirected from the musculature to the digestive system. The observation that *Thamnophis* did not select higher afternoon temperatures under dark conditions is consistant with its diurnal profile and leads us to the conclusion that light is the environmental cue which mediates this behaviour.

Acknowledgments

The authors thank M. Bernas, S. Justy, F. McCauley, R. W. McCauley and J. Poor for technical assistance. Funding was provided by NSERC grant (No. A2741) to F. F. Mallory.

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Received 22 September 1982
Accepted 17 September 1984

Notes

Possible Occurrence of Inter-specific Killing by a Columbian Ground Squirrel, *Spermophilus columbianus*

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Harris, M. A. 1985. Possible occurrence of inter-specific killing by a Columbian Ground Squirrel, *Spermophilus columbianus*. Canadian Field-Naturalist 99(2): 250–252.

A female Columbian Ground Squirrel (*Spermophilus columbianus*) was observed apparently killing a Meadow Vole (*Microtus pennsylvanicus*). This unusual behavior may have been related to defense of a nest site by the ground squirrel.

Key Words: *Spermophilus columbianus*, Columbian Ground Squirrel, Meadow Vole, *Microtus pennsylvanicus*, inter-specific killing, animal behavior, Alberta.

Predation has been noted for several species of ground squirrels. The group as a whole are omnivorous or opportunistic in their food habits, feeding on insects, eggs, fledgling birds, and other small mammals, and cannibalizing dead carcasses of their own species (e.g. Johnson 1922; Gordon 1943; Edwards 1946; Cahalane 1947; Sowls 1948; Mayer 1953; Bridgwater and Penny 1966). Columbian Ground Squirrels (*Spermophilus columbianus*), however, have been said to be "one of the most vegetarian of all the ground squirrels" (Shaw 1918). Predation on other vertebrate species has not been recorded, although cannibalism has been noted (Elliott 1978). Killing of juveniles by adult females without cannibalism has also been documented (Balfour 1983). McLean (1978) proposed that the plugging of nest burrows by females may be related to protection of their young from conspecific marauders. This paper describes an apparent instance of inter-specific killing, not related to predation, by a female Columbian Ground Squirrel.

These observations were made during studies on scent marking and social behavior in Columbian Ground Squirrels from 1976 to 1980 (see Murie and Harris 1978; Harris and Murie 1982). The study area covered about 4 ha near the Sheep River, 32 km west of Turner Valley, Alberta (50°38'N, 114°38'W). Within this main area were four observation areas of 1 ha, each monitored by a single observer. All squirrels in the study area were live-trapped and tagged through the ear with numbered #1 Monel fingerling fish tags, and squirrels on the observation areas were also individually dye-marked with Lady Clairol blue-black hair dye. Observers spent about four hours every morning scanning their area at 5-minute intervals with binoculars, noting the location and behavior of each squirrel on the area. Squirrels on the observation areas became accustomed to the presence of people, and, if the observer sat quietly, went about their normal activities seemingly undisturbed.

On the morning of 10 May 1976, I noticed that one of the females resident on the area suddenly ran out from beside a large boulder, approximately 20 m from where I was sitting, carrying a vole in her mouth. She ran with it about 15 m to a burrow entrance beside a small dirt mound; then she stood on her hindlegs and pushed the vole more firmly into her mouth with her forepaws, dropped it on the mound and held it down with her forepaws while biting at it, and moved around it from side to side in a quick and jerky fashion. She continued to worry at the vole for the next 10 minutes, her movements gradually becoming less agitated. During that time she disappeared partway into the burrow entrance and my view was partially obscured by clumps of grass. She then sat up on her hindquarters on the dirt mound and groomed for almost 5 minutes, clawing the ground and rubbing her body in the dirt as well as pawing and licking her fur. Following this she fed briefly on the vegetation beside the burrow and then went about her normal activities. About an hour and a half later, I investigated the spot where I had last seen the squirrel and vole. Beside the burrow entrance, half covered in dirt, was the entire body of a freshly killed Meadow Vole (*Microtus pennsylvanicus*). It had a large open wound on its neck and its neck was broken. There was no sign that it had been eaten.

Although in this case it is not certain that the vole was killed by the ground squirrel, it seems the most probable conclusion, since the squirrel's actions when

she first came into view suggested a struggle with a live object and the vole was only recently dead when I examined it. The fact that the squirrel did not eat the vole, even though her subsequent actions showed that she was not disturbed or frightened away from it, indicates that the killing was likely not predatory. Other information on the squirrel's activities leads me to suspect that the vole may have been killed because she discovered it in one of her nest burrows. This particular ground squirrel was a 2-year-old female who had bred on 3 May and who subsequently gave birth around 27 May. On 8 May she was observed to carry nest material (dry grass) to a small burrow entrance 3 m east of the same large boulder where I first saw her with the vole. Since she emerged each morning from a different burrow system, she could not have used this burrow as a nest herself, but she was evidently defending the area, since on three occasions she was observed to chase other squirrels from that locality. Later that year she provisioned two other burrows with nest material and eventually raised her young in one of these. She continued to live and breed in the same area for the next four years, during which time she maintained similar centres of activity. In 1977 and 1978 she again brought nest material to the burrow 3 m east of the large boulder, but never used it as a natal burrow. Also in 1978, on 9 May (about 2 weeks before giving birth), after spending a good part of the morning carrying nest material into this burrow, she was observed plugging the burrow entrance.

The incident described above may not have been isolated. On 14 May 1976 on another part of the observation area, I discovered the carcass of a vole lying beside the entrance to a burrow from which a female Columbian Ground Squirrel was seen to emerge in the mornings. This vole had been dead for some time and was partially covered with loose dirt and squirrel droppings. Similarly, A. Steiner (personal communication) on several occasions found dead voles on mounds or beside the entrances to squirrels' burrows during his studies on Columbian Ground Squirrels, which also took place in southwestern Alberta, mid-April to June, 1967 to 1969.

Female Columbian Ground Squirrels generally provision more than one burrow with nest material before giving birth, then choose one in which to raise their young (McLean 1978 and unpublished data). Around the middle of May they spend a good deal of time stocking small burrows with nest material, sometimes at a distance from their usual burrow systems. It is during this time, when pregnant female ground squirrels are obtaining and provisioning new nest sites, that they would seem most likely to come into conflict with other small ground-dwelling rodents.

These observations also suggest an additional or alternative explanation to that proposed by McLean (1978) for the plugging of nest burrows by female Columbian Ground Squirrels. It seems unlikely that the sole function of this behavior could be to protect their young from non-resident marauding conspecifics, since females sometimes plug burrows before they give birth, and after they give birth tend to plug burrows at night, when squirrels are underground, but open them up in the mornings, when squirrels are active. However, a well-concealed burrow already stocked with nest material might be a desirable resource for members of other sympatric species, such as Pocket Gophers (*Thomomys talpoides*), Deer Mice (*Peromyscus maniculatus*), or Meadow Voles, as well as for other members of their own species. The habit of female Columbian Ground Squirrels of plugging their nest burrows could have evolved to deter other individuals from discovering these ready-made homes and from taking them over between the time she stocks the nest and the time she gives birth.

Acknowledgments

I would like to thank L. Davis, J. Murie, and A. Steiner for their comments on the manuscript. The study was financed through NSERC grant A5865 to J. Murie.

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Received 19 August 1982
Accepted 7 November 1984

Revised Status of the Holly Fern, *Polystichum lonchitis*, in Ontario

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Mills, Alex. 1985. Revised status of the Holly Fern, *Polystichum lonchitis*, in Ontario. Canadian Field-Naturalist 99(2): 252–254.

The range of the Holly Fern (*Polystichum lonchitis*) in Ontario is more extensive than previously thought, based on six new stations from Thunder Bay, Algoma, and Manitoulin districts and Dufferin, Simcoe, and Peterborough counties. The extent of some of the geologic formations in which they are found suggest that the discovery of more stations is likely.

Key Words: Holly Fern, *Polystichum lonchitis*, Ontario, distribution.

Soper (1954) believed that the Holly Fern (*Polystichum lonchitis*) was confined in Ontario to suitable calcareous habitats in Bruce, Grey, and Simcoe counties, with disjunct stations in Welland county and Algoma district, and on this basis Argus and White (1977) included it in *The Rare Vascular Plants of Ontario*. Inspired by rumours of a wider distribution, a survey of ten major herbaria (DAO, Agriculture Canada; CAN, National Museums of Canada; TRT, University of Toronto; OAC, University of Guelph; WAT, University of Waterloo; QK, Queen's University; MCM, McMaster University; LKHD, Lakehead University; MIN, University of Minnesota; MICH, University of Michigan) was undertaken, revealing six new stations in Thunder Bay, Algoma, and Manitoulin districts and Dufferin, Simcoe, and Peterborough counties (Table 1 and Figure 1).

The Grey, Bruce, Simcoe and Welland stations reported by Soper (1954) are all found in the dolomitic limestones of a variety of middle and lower Silurian and upper Ordovician formations (Freeman 1979). These same formations are found at the new Manitoulin and Dufferin sites. Since this belt runs from western Manitoulin Island to the Niagara Glen, it would not be surprising to find the Holly Fern growing anywhere along its length, though much of it has already been thoroughly investigated by botanists. The Welland county station at Niagara Glen, first reported by Macoun (1890), may no longer be extant. Indeed, more recent specimens from there (e.g. Bert Miller *544*; 20 August 1948; MCM) may represent a reintroduction (J. S. Pringle, personal comment).

The middle Ordovician limestones of the Trenton and Black River groups (Freeman 1979) in which the new Simcoe stations are located extend many kilometers eastward south of the Canadian Shield, and the Peterborough county station is from a limestone outcrop in a complex geologic mosaic (Freeman 1979) typical of that latitude between Bancroft and Ottawa; more stations in these areas are possible as well.

The Algoma station reported by Soper (1954) is found in a region of Cambrian sedimentary rock (Ontario Geological Survey 1980), though Taylor (1938) noted that several of the specimens collected there were found in areas of lava and lava talus. The second Algoma site, presented here, is from the same Cambrian formation, and since this formation is restricted in Ontario to these few small patches along the Canadian shore of Lake Superior just north of Sault Ste. Marie, it does not indicate a more extensive Holly Fern range in that region. The Thunder Bay station is found in a Precambrian formation, also of sedimentary and volcanic rock (Ontario Geological Survey 1980), restricted in Ontario to the Lake Superior shore west of the Lakehead.

Montgomery (1944) reported that this species had been collected at Galt by Herriot, but, as there is no known specimen, the record was rejected by Campbell

TABLE 1. Holly Fern specimens representing new Ontario stations. Herbaria codes are given in the text. MICH and MIN accession by collector field numbers.

Number on Map	Location	Coordinates	Date	Collector	Herbarium
1.	Thunder Bay District; Cloud Bay	48°05′N 89°25′W	08 July 1939	D. L. Jacobs-16	MIN
2.	Algoma District; Tarantorus Township	46°37′N 84°09′W	04 September 1957	S. T. B. Losee	LKHD *037079*
3.	Manitoulin District; Carnarvon Township	45°42′N 82°14′W	05 July 1981	J. Morton, J. Venn	OAC *61258*
4a.	Simcoe County; Orillia Township	44°46′N 79°26′W	11 June 1974	A. A. Reznicek-4102	MICH
4b.	Simcoe County; Orillia Township	44°44′N 79°36′W	14 June 1976	A. A. Reznicek	TRT *194575*
5.	Dufferin County; Mono Center	44°02′N 80°04′W	16 September 1982	A. M. Mills	OAC *62832*
6.	Peterborough County; Apsley	44°47′N 78°06′W	10 August 1960	D. M. Wood	TRT *121483*

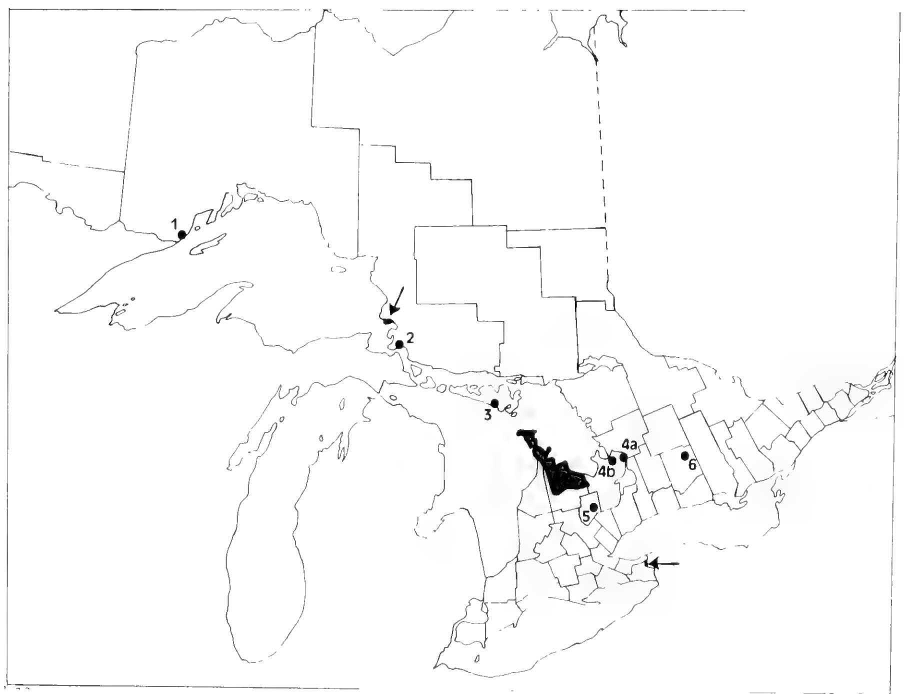

FIGURE 1. Ontario Holly Fern range as indicated by Soper (1954) (solid and two arrows) and new records (numbered stations, as explained in Table 1).

and Britton (1977). As Boivin (1980) has recommended, unusual Galt area records of Herriot's should not be accepted without adequate confirmation due to his introduction activities and confusion between mailing addresses and collecting sites. Fernald (1935) indicated that the Holly Fern was known from the north shore of Lake Erie (apparently near St. Thomas, judging from Fernald's map); however, Soper (1954) discounted the record. According to G. P. Bell (personal comment), a specimen he collected (QK *114541*) along the Niagara Escarpment in Simcoe county is erroneously labelled Minesing, Ontario.

It appears that the range of the Holly Fern in Ontario is more extensive than previously thought. The core is still focused in the Bruce Peninsula region, but stations exist along the south edge of the Canadian Shield, more extensively along the Niagara Escarpment, on Manitoulin Island, and along the Lake Superior shore.

Acknowledgments

I wish to thank D. M. Britton and W. J. Cody for commenting upon earlier drafts of the manuscript. Certain herbarium labels were clarified by G. W. Argus, W. E. Cattley, G. B. Ownbey, and A. A. Reznicek. J. S. Pringle provided information on the Welland county station.

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Received 1 December 1983
Accepted 24 September 1984

Occurrences of Black-necked Stilts, *Himantopus mexicanus*, in Western Canada

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Chapman, Betty-Ann, J. Paul Goossen, and Isabel Ohanjanian. 1985. Occurrences of Black-necked Stilts, *Himantopus mexicanus*, in Western Canada. Canadian Field-Naturalist 99(2): 254–257.

Recent Black-necked Stilt (*Himantopus mexicanus*) records in Canada include British Columbia's second interior record and Canada's fourth successful nesting. It is suggested that the status of the Black-necked Stilt be changed to occasional spring visitor in British Columbia and Saskatchewan, occasional visitor (spring, summer and fall) in Manitoba and occasional spring visitor and summer resident in Alberta.

Key Words: Black-necked Stilt, *Himantopus mexicanus*, western Canada, status, distribution, breeding, weather.

In recent years Black-necked Stilts (*Himantopus mexicanus*), have been sighted in the western provinces of Canada. Godfrey (1966) listed only the disputed set of eggs collected at Qu'Appelle, Saskatchewan in 1894, which he later discounted (Godfrey 1969). In 1981 six birds were seen in British Columbia, the largest number to date in any one year in that province.

On 10 May 1981, Chapman and Ohanjanian saw a Black-necked Stilt in the Creston Valley Wildlife Management Area near Creston, British Columbia. The bird was observed first at 1400 with other shorebirds at the edge of exposed mud flats at the southwestern end of Duck Lake. The stilt was still present at 1900 when it was photographed by Goossen and observed by Rob Butler and Scott Forbes (British Columbia Provincial Museum Photofile No. 946, Campbell and Stirling 1971), but never seen again subsequently. That was the second observation of a Black-necked Stilt in the interior of British Columbia. During the same spring, from 21 April until 4 May, up to five Black-necked Stilts were observed on the coast near Delta, British Columbia (Hunn and Mattocks 1981; R. W. Campbell and W. Weber, British Columbia Provincial Museum and Ministry of Agriculture respectively, personal communication). Most recent sightings in western Canada are from the two westernmost provinces (Figure 1). Possible sight records were mentioned for southwestern Manitoba in McNicholl et al. (1972). Breeding records for Canada are limited to Alberta (Table 1). On 23 July 1980, two adults and two young were photographed (C. Gordon, Canadian Wildlife Service, personal communication) near New Dayton, the fourth successful nesting in Canada. This is the same sighting mentioned in Gollop (1981b), where the details given are incorrect. All four successful nests have been in Alberta. Also Dekker et al. (1979) listed one of two nests at Beaverhill Lake, Alberta in 1977 with seven eggs while Serr (1977) noted six eggs, however one of the seven eggs was missing before hatching (McNicholl 1982). Since nesting records have been established as far north as Edmonton, the possibility that the eggs found in Qu'Appelle in 1894 were Black-necked Stilt eggs is more plausible (Houston 1984; Kreba 1983).

Of the 28 records with dates (Table 1), 23 were in spring (April-June), while four occurred in the summer (July-August) and only one in the fall (October). Only spring sightings are known in Saskatchewan and British Columbia, and the vast majority of Alberta's records were also spring sightings. Manitoba had only one spring occurrence compared to three in the summer and one in the fall.

Stilts moving away from their usual range apparently are adults and not simply juveniles dispersing. Drought conditions in southern areas were suggested as resulting in occurrence of stilts outside their usual range in 1977 (Dekker et al. 1979; Rohwer et al. 1979). Also the sight records are biased by the activity and location of observers. More birding is done in the spring with most birders localized in urban areas. As the occurrence of Black-necked Stilts in western Canada is becoming more frequent, we suggest that the status of the Black-necked Stilt in those provinces

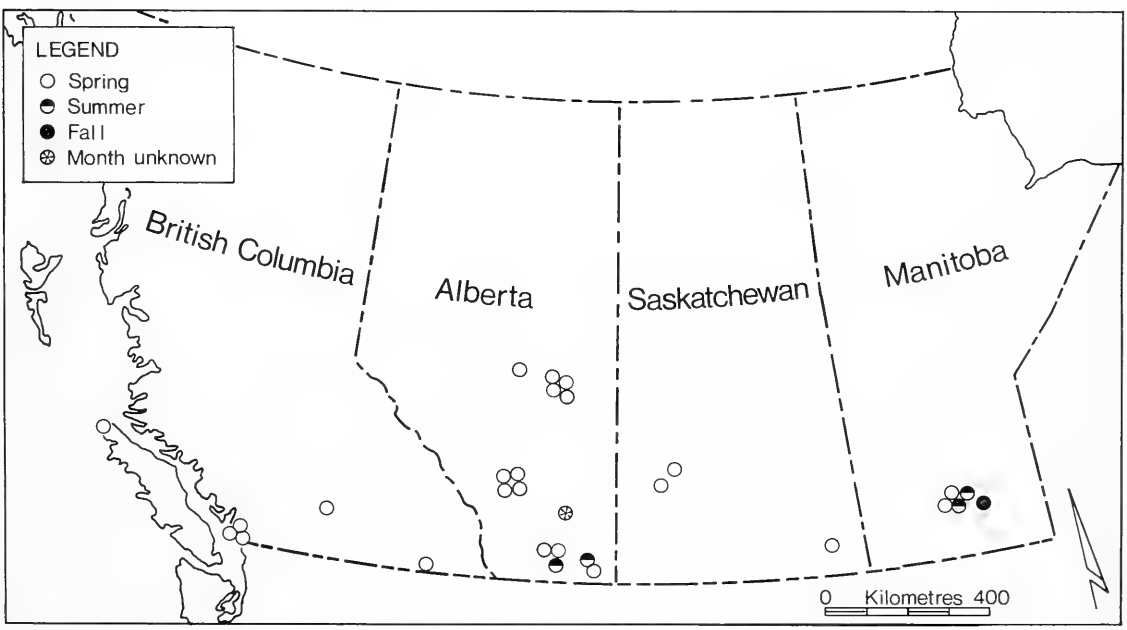

FIGURE 1. Black-necked Stilt records for western Canada.

TABLE 1. Records of Black-necked Stilt sightings for western Canada

Date	Area	Number seen	Reference
Manitoba			
17 April 1981	Delta	1 adult	Gollop 1981a
10 June-31 July 1980	Delta	1 adult	Gollop 1980b
21–29 October 1978	Oak Hammock Marsh	1 adult	Gardner 1978
9–10 August 1969	St. Ambroise	1 adult	McNicholl et al. 1972
13 July 1969	Delta	1 adult	McNicholl et al. 1972
Saskatchewan			
5 June 1977	Richlea	8 adults	A. R. Smith, personal communication
7 May 1971	Rosetown	1 adult	Renaud and Renaud 1975
20 May 1955	Arcola	3 adults	McLellan 1955
Alberta			
3 August 1982	Pakowki Lake	2 adults	Gollop 1982
15 May 1982	Pakowki Lake	1 adult	Gollop 1982
30–31 May 1981	Lethbridge	2 adults	Wisely 1982
23 July 1980	New Dayton	2 adults, 2 young	C. Gordon, personal communication
11 May 1980	Airdrie	1 adult	Gollop 1980a
4 May 1980	Calgary	1 adult	Brooks 1980
3 May 1980	Beaverhill Lake	1 adult	Gollop 1980a
June 1977	Beaverhill Lake	4 eggs, 7 eggs	Dekker et al. 1979
11 May 1977	Stirling Lake	1 adult	A. R. Smith, personal communication
3 May 1977	St. Albert	2 adults	Dekker et al. 1979
24 May 1972	Irricana	1 adult	Weseloh and McKay 1972
12 May 1970	Longdon	1 adult	Weseloh 1972
22 May 1960	Beaverhill Lake	1 adult	Gammell 1960
mid 1950's	Brooks	dead bird	Salt and Salt 1976
British Columbia			
10 May 1981	Creston	1 adult	this report
21 April-4 May 1981	Westham Island	5 adults	R. W. Campbell, personal communication
9 May 1978	Douglas Lake	1 adult	R. W. Campbell, personal communication
17 May 1974	Hansen's Lagoon	1 adult	Roberson 1980
4–7 April 1974	Sea Island	1 adult	Roberson 1980
13–14 May 1971	Sea Island	1 adult	Campbell and Anderson 1972

should be changed to occasional spring visitor in British Columbia and Saskatchewan, occasional visitor (spring, summer and fall) in Manitoba and occasional spring visitor and summer resident in Alberta.

Acknowledgments

N. A. M. Verbeek, D. R. Flook, D. D. Moore and the staff of the Creston Valley Wildlife Management Area provided logistic support. Financial support was incidental to another project funded by NSERC (grant no. A0239) to N. A. M. Verbeek. R. W. Campbell, C. Gordon, A. R. Smith and W. Weber supplied details on unpublished sightings. R. Butler, L. S. Forbes, N. A. M. Verbeek and W. Weber reviewed the manuscript. L. Strembitsky and S. Popowich of the Canadian Wildlife Service typed an earlier version of the manuscript and drew the figure respectively.

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Received 31 August 1983
Accepted 19 November 1984

Interbreeding of Thayer's Gull, *Larus thayeri*, and Kumlien's Gull, *Larus glaucoides kumlieni*, on Southampton Island, Northwest Territories

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Gaston, A. J., and R. Decker. 1985. Interbreeding of Thayer's Gull, *Larus thayeri*, and Kumlien's Gull, *Larus glaucoides kumlieni*, on Southampton Island, Northwest Territories. Canadian Field-Naturalist 99(2): 257–259.

Gulls with the characteristics of Thayer's and Kumlien's gulls, *Larus thayeri* and *Larus glaucoides kumlieni*, were found apparently interbreeding at a colony on Bell Peninsula, eastern Southhampton Island. The taxonomic status of *L. thayeri* may require re-evaluation.

Key Words: Thayer's Gull, *Larus thayeri*, Kumlien's Gull, *Larus glaucoides kumlieni*, taxonomy.

Thayer's Gull, *Larus thayeri*, breeds from Banks Island to Ellesmere Island in the Canadian arctic archipelago and as far south as Southampton and Coats Islands in Hudson Bay. Originally considered a race of the Herring Gull, *Larus argentatus*, (Dwight 1917), Thayer's Gull was shown by Macpherson (1961) and Smith (1969) to be specifically distinct from that species. Kumlien's Gull, *L. glaucoides kumlieni*, is confined to south and east Baffin Island and the northwest tip of the Ungava Peninsula (Smith 1969; A. O. U. 1957). Macpherson (1961) considered Thayer's and Kumlien's Gulls to be conspecific but Smith (1969) found no natural hybridization between the two forms in an area of sympatry at Home Bay, eastern Baffin Island.

In eastern Baffin Island the two species could be distinguished on the basis of wing-tip coloration (dark in Thayer's, pale in Kumlien's) and iris colour (speckled purple in Thayer's, yellow in Kumlien's). According to Smith, although both species are very variable, Thayer's Gulls throughout their range always have extensive areas of black or brown pigmentation at the tips of the five longest primaries and at least some pigmentation in the iris, whereas typical Kumlien's Gulls have the dark pigmentation in the wing-tips only on the outer webs and frequently have

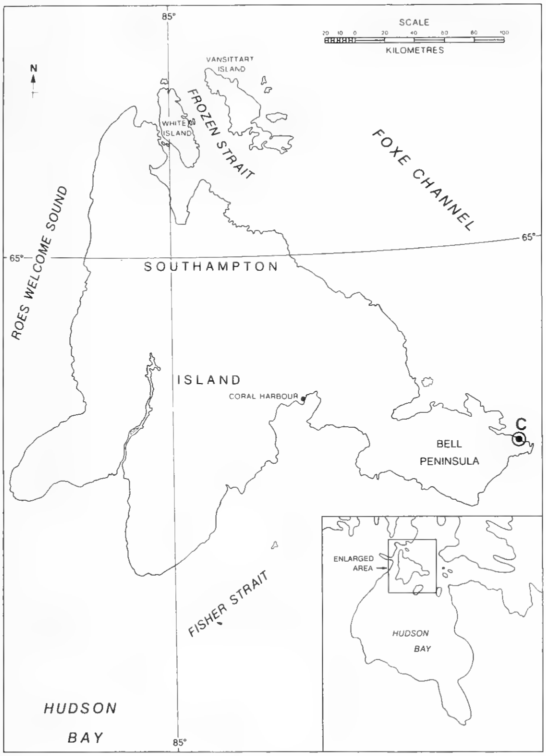

FIGURE 1. Southampton Island, showing the position of the colony visited (C)

clear yellow irides. The wing-tips of Kumlien's Gulls are never darker than medium grey. In both species the eye-ring is normally reddish-purple.

In the course of seabird colony surveys around Southampton Island in June 1983 we located a mixed colony of Thayer's and Kumlien's Gulls on the northeast coast of the Bell Peninsula (Figure 1). That colony was not visited by Smith. We visited the colony on the ground on 29 June and estimated that 90–100 birds were present, many of which were incubating. The nests were situated on cliffs about 80 m high, facing seaward, but we were able to climb close to the colony and examine birds through binoculars at ranges down to 10 m. We made field notes of plumage and soft parts for all individuals we could see clearly and recorded where courtship or greeting behaviour suggested that birds were paired.

Plumages exhibited among birds seen well ranged from typical Thayer's, with blackish tips to the primaries, enclosing prominent white windows, to typical Kumlien's, with virtually unmarked tips to the primaries, merely faint traces of pale brown on the outer web. At least two individuals appeared intermediate, with medium brown markings on the primaries distributed in exactly the same fashion as the typical Thayer's. The pattern on the primary feathers was recorded for 43 birds, of which 25 (58%) appeared typical Thayer's and 16 (37%) typical Kumlien's.

All the birds present had dark eye-rings. Some had dark (presumably purple, Smith 1969) irides, while others had yellow irides and some appeared intermediate. No correlation was apparent between the colour of the primaries and the irides; birds with both Thayer's and Kumlien's wing patterns had yellow and dark irides. The two intermediate birds both had dark irides, as did 18 out of 24 (75%) birds seen adequately.

Plumage was satisfactorily described for twelve apparently mated pairs, of which all but two were incubating. Of that sample, 17 individuals were Thayer's and 7 Kumlien's, forming six pairs of Thayer's/Thayer's, five of Thayer's/Kumlien's and one Kumlien's/Kumlien's. That is close to the ratio predicted by an assumption of random pairing between the two species (50% T/T : 40% T/K : 10% K/K).

Our observations differed from those of Smith at Home Bay in showing a lack of assortative mating between the two species. It is also interesting to note that the proportion of birds with dark irides was 75%, similar to the proportion of Kumlien's Gulls with dark irides recorded by Smith in southwest Baffin Island; the nearest population of Kumlien's Gulls to eastern Southampton Island.

Several possible explanations may reconcile our observations with those of Smith (1969):

(1) the "Kumlien's Gulls" that were observed were actually unusually pale-winged Thayer's Gulls;
(2) the mixed pairs that we observed were an unusual phenomenon not typical of the colony;
(3) species isolating mechanisms between these two "species" have recently begun to break down; or
(4) Thayer's and Kumlien's Gulls interbreed without assortment on eastern Southampton Island.

All of the first three explanations invoke statistically unlikely events and the fourth seems the most parsimonious. Smith noted that, among Thayer's and Kumlien's Gulls, there is a positive correlation between iris pigmentation and the amount of pigment in the primaries. Kumlien's gull is extremely variable, with birds ranging from those with all white primary tips, as in the nominate *L. g. glaucoides* of Greenland, to those similar to the "intermediate" birds we describe here. According to Smith, the more pigmented phenotype becomes more common from northeast to southwest through the species range. If that is so, it is easy to see that the two forms might interbreed freely in the small area of sympatry on eastern Southampton Island, where the phenotypes are least distinct. The majority of Kumlien's Gulls at Digges Sound, the

most southwesterly part of the species' range and 200 km southeast of Southampton Island, have dark irides (Gaston unpublished). If Smith's contention that iris and eye-ring colour and contrast are the most important characters allowing interspecific segregation among arctic gulls is correct then, with Kumlien's and Thayer's Gulls in the northern Hudson Bay area overlapping extensively in this character, interbreeding is hardly surprising. A single Thayer's Gull was paired with a Kumlien's Gull at Digges Sound in 1980 and 1981 (Gaston unpublished).

If our explanation for the observed lack of mating preferences among Thayer's and Kumlien's Gulls in an area of sympatry is correct, what implications does it have for taxonomy? The two species interbreed in one part of their range, but apparently remain distinct at another. The situation may be analogous, on a small scale, to the subspecies rings described for the Herring Gull and other species by Mayr (1963). Our observations tend to support Weber's (1981) suggestion that Kumlien's and Thayer's Gulls are conspecific. However, further field research will be necessary before a definitive statement on their taxonomy can be made.

Acknowledgments

We would like to thank Hugh Boyd, Graham Cooch and W. Earl Godfrey for comments on this manuscript.

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Received 24 November 1983
Accepted 18 October 1984

The Effect of pH on Bullfrog, *Rana catesbeiana*, and Green Frog, *Rana clamitans melanota*, Tadpoles

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Static bioassays were performed on Bullfrog (*Rana catesbeiana*) and Green Frog (*Rana clamitans melanota*) tadpoles to determine acute pH levels. Results indicate a sharp increase in percent mortality, for both species, between pH levels of 4.3 and 4.2.

Key Words: Bullfrog, *Rana catesbeiana*, Green Frog, *Rana clamitans melanota*, acute toxicity, acid precipitation.

The effects of pH on amphibians and the optimal pH levels have been described by Pough (1976), and Pough and Wilson (1977), for the fertilization and development of *Ambystoma* eggs, and by Schicter (1981) for fertilization of *Rana pipiens* eggs. Tome and Pough (1982) reviewed the impacts of acid precipitation on amphibians and discussed possible mechanisms producing death in embryos and tadpoles. Seasonal variation in pH could be important in lakes which are breeding sites for the Bullfrog *Rana catesbeiana*, and the Green Frog, *Rana clamitans melanota*. Many lakes have been shown to have low pH values during spring snow-melt: Beamish (1974) measured pH values of 4.5 during spring months in Muriel lake, Ontario, throughout its depths (to 12.5 m). Yan and Stokes (1978) showed that the pH of Carlyle lake,

Ontario, decreased by over one pH unit during the 1974 spring snow-melt. The pH at that time was uniform (4.4–4.5) down to the bottom of the lake (12 m). Hultberg (1977) reported that pH dropped from 5.0 to 3.4 just below ice-cover, and to 3.8 at 1 and 5 m depths, during winter and early spring months in three swedish lakes. This condition lasted between 14 to 30 days. Similar pH depressions, in the first few meters of lake water, were reported in Ontario lakes by Scheider et al. (1979).

The purpose of this study was to determine critical pH levels for Bullfrog and Green Frog tadpoles. These species have tadpoles that develop over a 1- or 2-year period in small to large permanent bodies of water, and therefore can be subjected to a wide fluctuation in pH level during their larval period.

Bullfrog tadpoles were collected from Lake St-Louis on 5 October 1981. Green Frog tadpoles were taken from Stoneycroft pond on 12 November 1981. Both collection sites are located on Macdonald Campus in Ste-Anne de Bellevue, Quebec (45 24′N, 74 05′W). The pH of the water, at collection time, for Lake St-Louis was 6.7, and at Stoneycroft pond, 7.1. Tadpoles were brought into the lab and kept in a supply tank filled with distilled water at pH 6.7. This water was oxygenated using an air stone. All tadpoles were between developmental stages 25 to 30 (Gosner 1960). Temperature was maintained throughout the experiment at 20°C.

A stock acidic solution was prepared by mixing reagent grade sulphuric (H_2SO_4) and nitric acid (HNO_3) in a ratio of 7:3 which best represents the average ratio found in acid precipitation (Brosset 1973; Likens and Bormann 1974). Minute quantities of stock solution were added to 2 litres of distilled water to create acid water at experimental pH levels.

Three replicates were used each consisting of a group of six containers as follows: one control with distilled water at pH 6.7, the remaining five containers filled with acid water at different pH levels between 3.6 and 6.4. The pH levels tested were: 3.6, 3.8, 4.0, 4.1, 4.2, 4.3, 4.4, 4.5, 5.3, and 6.4. Experiments were performed until 30 tadpoles had been exposed to each pH level. The tadpoles were kept in these containers for four days and all deaths recorded. The pH was measured daily but remained relatively constant, increasing by no more than 0.2 pH units. Preliminary tests indicated that a 4-day period was sufficient to determine acute pH levels. After four days, bioassay solutions and control water were changed and new tadpoles were tested. The control animals remained the same throughout the experiment.

The percentage of Bullfrog tadpoles which died over four days was high for all pH levels less than 4.3 (Figure 1). Percent mortality increased from near 0 at pH 4.3 to 78% at pH 4.2. The percent mortality continued to increase as the pH was lowered, eventually reaching 100% at pH 3.9. Similar results were found for Green Frog tadpoles (Figure 1). Death occurred very rapidly, usually within one day. Below pH 4.5, the skin of dead tadpoles turned milky white and even flaked off in the most acidic test solutions.

The critical range in pH between 4.2 and 4.3 for both species is consistent with the findings of Gosner and Black (1957), Pough (1976) and Pough and Wilson (1977) for fertilization and embryonic development of other amphibian species. As these tests were performed in distilled water, one might suspect that deaths recorded are a result of increasing H^+ ion concentration alone, and not due to other parameters such as heavy metals.

Comparison with results summarized in Tome and Pough (1982) suggest that Bullfrog tadpoles are affected at the same pH levels as embryos, but Saber and Dunson's (1978) results, on toxicity of bog water to larval Bullfrogs, indicate that tolerance to pH increases with increasing larval development. Green Frog larvae also appear to be slightly more tolerant to low pH than their embryonic stages (Tome and Pough 1982).

Both species in this study breed in permanent bodies of water sufficiently deep (4–5 m) to prevent complete freeze-up during winter. Although snow melt-water in spring will likely have a greater short-term impact on species breeding in small temporary ponds (such as the Wood Frog, *Rana sylvatica*, and the Spring Peeper, *Hyla crucifer*), because of the relatively smaller volume of water present in some of these habitats at the time of snow-melt, some authors (Beamish 1974; Hultberg 1977; Yan and Stokes 1978), have shown that drops in pH close to the critical values found in this study could also occur during spring snow-melt in larger bodies of water.

Tadpoles of these two species could be affected by (1) short-term acidification events (especially spring snow-melt) which (a) can affect all depths in certain lakes of the Precambrian shield (Yan and Stokes 1978) and which could cause major kill-offs of tadpoles, or (b) acidify only surface waters during late winter and early spring months (Hultberg 1977), forcing tadpoles to deeper parts of lakes where there are low oxygen concentrations or high predation; and (2) the slow and gradual acidification of aquatic habitats reported by Cogbill (1976), Wright and Gjessing (1976), Seip and Tollan (1978), and Scheider et al. (1979) which could be a long-term hazard.

Acknowledgments

We thank Drs. D. J. Lewis, G. J. Doucet, A. F. MacKenzie, G. Moreau and Mr. S. Savage for their valuable assistance.

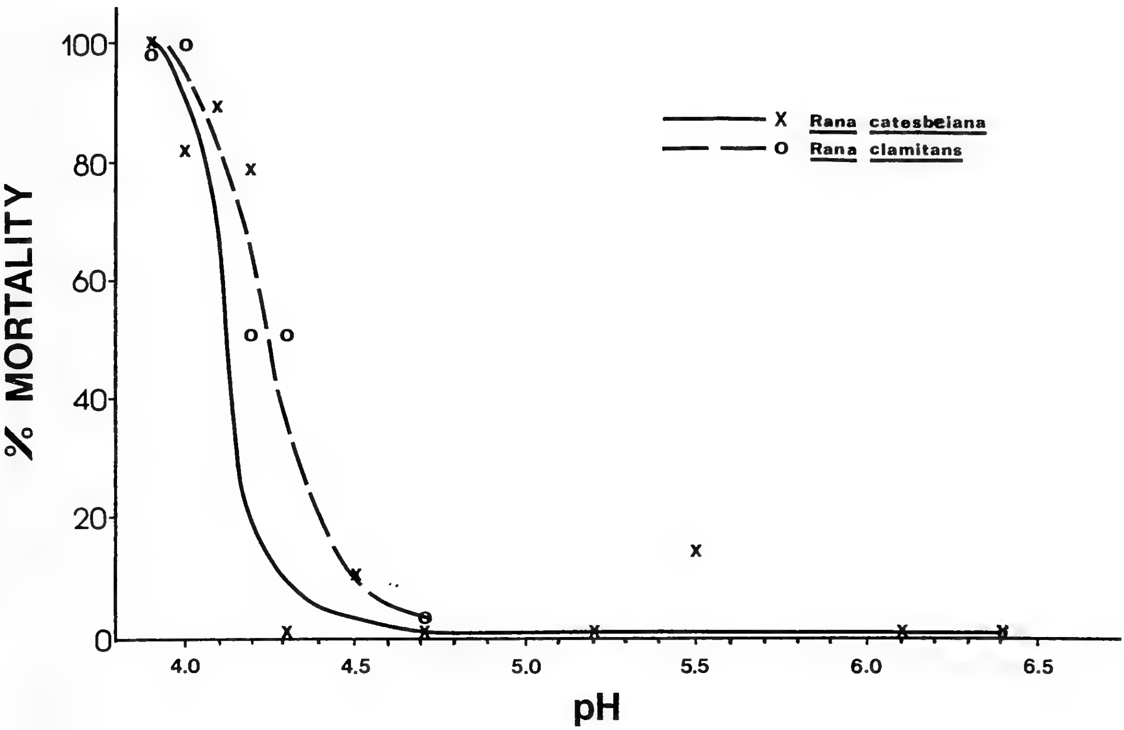

FIGURE 1. Mortality rates of frog tadpoles versus pH.

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Received 30 March 1983
Accepted 28 August 1984

Flexible Dietary Response and Feeding Ecology of the Red-shouldered Hawk, *Buteo lineatus*, in Iowa

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We observed that mammals comprised 92% of the identified prey items brought to three Red-shouldered Hawk (*Buteo lineatus*) nests in Iowa during a drought in 1977. The following year, 85% of the prey items delivered to four nests in the same study area were amphibians and arthropods. The nesting territories were mostly covered by shallow water in 1978, and mammal densities were probably reduced causing the hawks to switch to available alternate prey.

Key Words: Red-shouldered Hawk, *Buteo lineatus*, diet flexibility, prey switching, Iowa.

Several workers (e.g. Craighead and Craighead 1956; Smith and Murphy 1979; Smith et al. 1981; Baker and Brooks 1981) have examined the response of raptor populations to changing densities of their prey species. Although the numerical response of raptors has been well documented (Newton 1976), pronounced switching to an alternate prey species (or functional response) has not received as much attention (Phelan and Robertson 1978). Craighead and Craighead (1956:301) noted that Red-shouldered Hawks (*Buteo lineatus*) in Michigan shifted from a diet clearly dominated by Meadow Voles (*Microtus pennsylvanicus*) in the winter to one that included mammals, birds, snakes, frogs, and crayfish in the spring and summer. The Meadow Vole, however, was still the most abundant prey species in the food remains, and the diets of breeding hawks were similar in both years of their study (Craighead and Craighead 1956:276). Adamcik et al. (1979), in a 10-year study, showed that mammals dominated the percentage frequency and biomass of the diet of breeding Red-tailed Hawks (*Buteo jamaicensis*), but during cyclic lows of Snowshoe Hares (*Lepus americanus*) a partial dietary shift to waterfowl occurred, which was accompanied by a severe reduction in productivity. Here, we describe a dramatic shift in the diet of a small breeding population of Red-shouldered Hawks inhabiting the Mississippi River floodplain in northeastern Iowa.

Methods

We identified prey items brought to three nests in 1977 (62 hrs) and four nests in 1978 (121 hrs) by watching from blinds located 30-70 meters from the nests. Observations during both years began when nestlings were approximately one week old and were continued through fledging. Three nests observed in 1978 were within the nesting territories studied in 1977. The relative proportions of different prey remains in castings collected beneath nests were determined by identifying 25 random samples (Chamrad and Box 1964) taken from each of 40 pellets and 11 pellet fragment consolidations ($51 \times 25 = 1275$ samples). A pellet fragment consolidation included all incomplete pellets collected from underneath a nest at the same time. Mammal hair was identified using a reference collection and the characteristics given by Moore et al. (1974). In 1977, the small mammal species available in marsh edge habitat and floodplain forest were determined by snap trapping (30 traps set on each of seven consecutive nights in each habitat). Trapping could not be done in 1978 because nesting territories were flooded. Chi-square statistics were calculated based on the number of mammal and other prey occurrences recorded.

Results

The proportion of mammal and other prey were significantly different between years, both for items brought to the nest (Table 1; $X^2 = 68$, $P < 0.001$, d.f. = 1) and in pellets (Table 2; $X^2 = 131$, $P < 0.001$, d.f. = 1). In 1978, mammals were the dominant prey in pellets (Table 2), but comprises less than 8% of the items brought to the nest (Table 1). Pellet analyses are seriously biased in that amphibian, reptile, and crayfish remains are poorly represented (Craighead and Craighead 1956: 276; Snyder and Wiley 1976: 6; Portnoy and Dodge 1979). Excluding the unidentified food items, mammals comprised 92% of the food items brought to nests in 1977, but only 10% of the items in 1978 (Table 1).

Both observations and pellet analysis showed similar ratios between the numbers of Meadow Voles and *Peromyscus* spp. in the diet (4:1). By either method, Meadow Voles were an important part of the red-

TABLE 1. Percentage of different food items brought to Red-shouldered Hawk nests in 1977 and 1978.

	Year	
Food Item	1977 N = 58	1978 N = 106
Mammals	56.9	7.5
Amphibians[a]	3.4	34.0
Arthropods[b]	0.0	28.3
Reptiles[c]	0.0	2.8
Birds	1.7	1.9
Unidentified	37.9	26.4

[a]*Rana pipiens* and *R. catesbeiana* were identified.
[b]Crayfish (Cambaridae) and caterpillars.
[c]*Thamnophis sirtalis* and *Nerodia sipedon* were identified.

TABLE 2. Percentage of different prey by occurrence represented in Red-shouldered Hawk pellets in 1977 and 1978.

	Year	
Food Item	1977 N = 375	1978 N = 900
Microtus pennsylvanicus	70.1	38.4
Peromyscus	16.5	13.6
Other mammals[a]	3.7	5.1
Total Mammals	90.3	57.1
Bird feathers	9.4	22.7
Crayfish	0.0	9.8
Insects	0.3	9.8
Other[b]	0.0	0.6

[a]Shrews (Soricidae), *Ondatra zibethicus* (Muskrat), *Reithrodontomys megalotis* (Western Harvest Mouse), *Tamias striatus* (Eastern Chipmunk).
[b]Unidentified snake and frog.

shoulder diet. Most of the feathers found in pellets (Table 2) were hawk-like down feathers and probably were accidently swallowed during preening; thus, they do not represent prey items. The higher incidence of feathers in pellets in 1978 (Table 2) was probably due to the consumption of fewer mammals and the resultant lower rate of pellet production in that year. More pellets were found in 1978 only because of an intensive search done in that year.

Discussion

We believe the major shift in prey types between years (Table 1) was associated with changes in water levels in the Mississippi River backwaters and marshes. A severe drought occurred in 1977, whereas water levels were higher than normal in 1978. Mean tailwater elevations (water level below dam) at nearby Lock and Dam No. 9 were 1.06 m higher in March-June 1978 than in 1977 (unpublished data, U.S. Corps of Engineers, Lock and Dam No. 9, Lynxville, Wisconsin). During the 1978 breeding season, much of the hawk nesting territories were covered by shallow water and hence a severe decline in mammal densities probably occurred. Amphibians and crayfish were not censused, but they were obviously abundant in 1978, while only a few anurans and no crayfish were seen during the 1977 drought.

Breeding Iowa red-shoulders primarily restrict their activity to floodplain forests and associated marshes and wet meadows (Bednarz and Dinsmore 1981). *Microtus*, which made up the bulk of the 1977 diet (Table 2), were trapped only at the edge of the marsh and not in the floodplain forest. *Peromyscus* were trapped in both marsh edge and floodplain forest habitat. All of the primary prey animals (Meadow Voles, amphibians, and crayfish; Tables 1 and 2) in the study area were generally restricted to marshes and wet meadows, suggesting the importance of those habitats as hunting areas for nesting Red-shouldered Hawks.

Productivity was excellent in both years (9 young from three nests in 1977 and 14 young from four successful nests in 1978). Campbell (1975) suggested that a long-term decrease in reptiles and amphibians and an increase in mammals may contribute to the replacement of red-shoulders by Red-tailed Hawks and Great Horned Owls (*Bubo virginianus*). Our results showed that, with short-term changes in water levels, red-shoulders adapted to the available prey and were capable of successfully raising young with either mammal or alternative prey. We suggest that the red-shoulder does not depend on any particular kind of prey, but rather, is adapted to the forested floodplain system (Bednarz and Dinsmore 1981) and its varying frequencies of prey types.

Acknowledgments

We are grateful to J. Wagner and R. Ervin who assisted in the field and to G. A. Thibodeau, E. Klaas, A. J. Erskine, B. Woodward, S. B. Peterson, D. G. Smith, and J. D. Ligon who reviewed earlier versions of this manuscript. Funding was provided by the U.S. Fish and Wildlife Service (Migratory Bird Program) through the Iowa Cooperative Wildlife Research Unit (U.S. Fish and Wildlife Service, Iowa Conservation Commission, Iowa State University, and Wildlife Management Institute cooperating), Hawk Mountain Sanctuary Association, and Iowa Agriculture and Home Economics Experiment Station. This is Journal Paper No. J-10265 of the Iowa Agriculture and Home Economics Experiment Station, Project No. 2170.

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Received 10 August 1983
Accepted 20 September 1984

First record of the Bitterroot, *Lewisia rediviva*, in Alberta.

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Kuijt, Job, and Gail R. Michener. 1985. First record of the Bitterroot, *Lewisia rediviva*, in Alberta. Canadian Field-Naturalist 99(2): 264–266.

The Bitterroot (*Lewisia rediviva* Pursh) is reported for the first time for Alberta. Plants were found in exposed sites at about 1750 m elevation on two rocky ridges 22 km west of Pincher Creek. These populations are probably derived, by wind dispersal, from Bitterroot populations in southeastern British Columbia.

Key Words: Bitterroot, *Lewisia rediviva*, Alberta, wind dispersal.

In the summer of 1982 one of us (GRM), on a field trip in the Pincher Creek area of Alberta, found and photographed flowering specimens of a plant which was tentatively identified as the Bitterroot, *Lewisia rediviva* Pursh, a species hitherto not known east of the continental divide in Canada. A preliminary confirmation was made subsequently from senescent specimens in 1982 and final confirmation was made in 1983. The present note documents the existence of this remarkable flowering plant, the state flower of Montana, in Alberta.

We located two populations of the Bitterroot in southwestern Alberta, one 3 km north and the other 1.3 km east of Mt. Backus (22 km west of Pincher Creek, 49°26′N, 114°16′W). The original discovery took place on a ridge locally called Kylo Hill at the headwaters of Screwdriver Creek, at an elevation of approximately 1700 m. Like other ridges in the area, Kylo Hill is a ridge of tilted bedrock which runs parallel to the Rocky Mountain system nearby. The upper slopes on the southwest flanks are generally open and covered with fairly dense vegetation of *Stipa* sp., *Selaginella densa*, dwarf shrubs of *Rosa* sp. and *Amelanchier alnifolia, Sedum lanceolatum, Polemonium pulcherrimum, Artemisia campestris, Senecio canus,* and *Koeleria cristata*. In a few patches the prevailing winds and exposure have broken the sod (Figure 1), and the partly pulverized lithosol is completely exposed except for a few depauperate individuals of *Eriogonum ovalifolium, Potentilla hippiana, Erigeron compositus*, and *Agoseris glauca*. It is in such exposed patches that many Bitterroot plants are

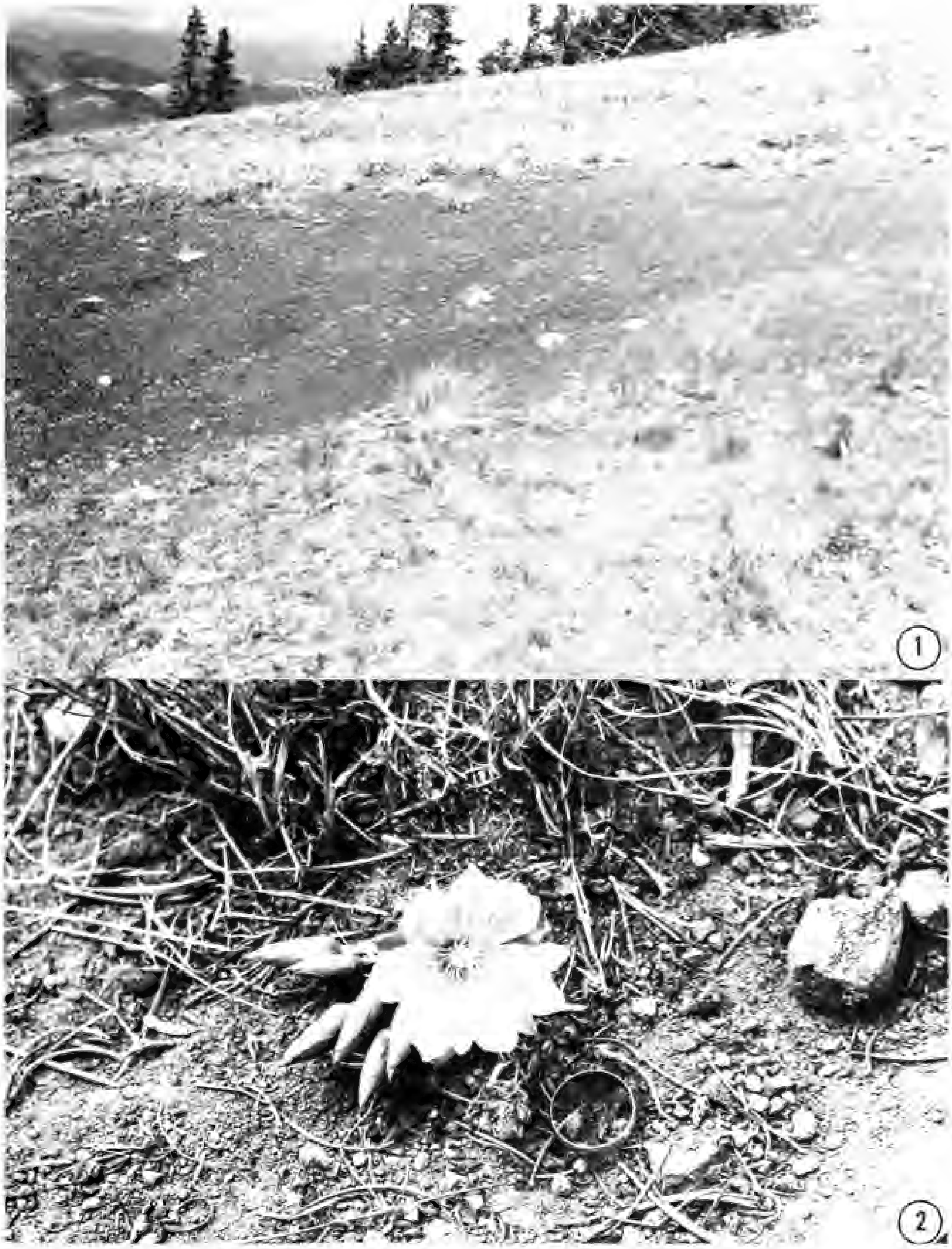

FIGURE 1. Northwesterly view of Bitterroot habitat on Kylo Hill. Senescent Bitterroot plants are no longer visible at this time (late July 1983). The white clumps are *Eriogonum ovalifolium*.
2. A flowering plant of the Bitterroot on Kylo Hill, 2 July 1983. Diameter of ring 18 mm.

found. Additional plants of the Bitterroot are present in exposed sites along the rocky crest of Kylo Hill to its summit. Similar "blowout" habitats occur along the crest as it continues northward and downward from the summit, but these do not support the Bitterroot.

The second population is on a ridge that runs east from Mt. Backus, at approximately the same elevation and with the same exposure as the first locality. Mt. Backus itself, although positioned between the two localities, appears to lack the Bitterroot, even though its southwestern slopes have much of the same habitat and vegetation represented. The easternmost prominent ridge in the area, Government Hill, similarly appears to lack the Bitterroot.

Both populations of *L. rediviva* extend across approximately one kilometer, from 1700 m to 1800 m in elevation. At Kylo Hill, a rough count in July 1983 located about 800 flowering plants; the second population is estimated to be of similar size. On both ridges, the plants are restricted to exposed areas on southwest facing slopes. Such areas receive thin and late-forming snow cover and, partly because of direct exposure to Chinook winds, become snow-free before any others at this elevation in the spring. This habitat preference agrees with the statement in Daubenmire (1975) that plants throughout their natural range tend to grow in areas which show "desiccation of soil early in the growing season." Temperatures in the Pincher Creek area occasionally go below -40°C; these are perhaps the lowest temperatures tolerated by the Bitterroot in any part of its range.

The flowering period of the Alberta populations is significantly later than the May-June period indicated by Daubenmire (1975) for specimens grown in Pullman, Washington. In 1983, flowering had just begun on 2 July and, judging from buds on 11 July in both 1982 and 1983, flowering probably extended to the third week of that month (Figure 2). The flowers and floral organs are a uniform, deep pink, in contrast to the variable flower color in more western populations (Daubenmire 1975).

The total geographical range of *L. rediviva*, detailed by Daubenmire (1975), includes extreme southern British Columbia at least as far north as Vernon, and all western states south to northern Arizona and Colorado. In the Pacific Northwest it is not known west of the Cascade Mountains. Until the present discovery in Alberta, the Bitterroot was known east of the continental divide only in the Yellowstone Valley of southern Montana. The nearest known localities to the Alberta populations are 80 km to the west in the Flathead valley of southeastern British Columbia, where it appears to be locally abundant on open, dry gravel benches at or near the valley floor, such as near Wasa, Elko, and Roosville.

The Bitterroot has had great importance as food for several Indian tribes of Western North America, and continues to do so in some cases (Elliott 1966). The Blackfoot Indians of southwestern Alberta are said to have used it (see Johnson 1970 and 1982, where the plant is erroneously called *Lewisia pygmaea* (A. Gray) Parry). However, except for the small populations of Bitterroot herewith reported, the historical geographic range (as presented by Johnston 1982) of the Blackfoot tribe is outside the range of the Bitterroot. This discrepancy implies trade for the roots with other Indians to the west and/or south of the Blackfoot range, if the Blackfoot did indeed use the Bitterroot.

The question should be raised whether the Alberta localities represent a relatively recent range extension or whether, instead, they form an older remnant of an originally continuous population. Daubenmire (1975), in noting discontinuities of range in the southwestern United States and possibly in Wyoming, suggested that range retraction from the south and east may be accompanied by northward extensions of range up the warm valleys of southern British Columbia. We suggest that wind dispersal of the seed cluster, the geographic position of the nearest population in the Rocky Mountain Trench, and the extremely strong and persistent southwesterly winds that characterize the area indicate that the Alberta populations are recently derived from those in southeastern British Columbia.

Herbarium specimens have been deposited in the herbaria of the University of Lethbridge, of the University of Alberta, and of the National Museum of Natural Sciences, Ottawa.

Acknowledgments

We are grateful for field assistance given by Dr. D. H. Sheppard, for financial support from the Natural Sciences and Engineering Research Council of Canada, and to Dr. A. R. Olson for help in photographic work.

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Received 5 December 1983
Accepted 17 September 1984

Age and Sex of Trapped Lynx, *Felis canadensis*, Related to Period of Capture and Trapping Technique

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Quinn, Norman W. S., and John E. Thompson. 1985. Age and sex of trapped Lynx, *Felis canadensis*, related to period of capture and trapping technique. Canadian Field-Naturalist 99(2): 267–269.

Several features of the age and sex structure of the harvest of Lynx, *Felis canadensis*, in Ontario are presented. Yearlings dominated the harvest but declined over time although yearling males recurred in large numbers in February. Kits increased markedly in the harvest after December. Male Lynx may be more vulnerable to leghold traps than females. Results are attributed to age and sex-related differences in behaviour of Lynx.

Key Words: Age, leghold trap, Lynx, *Felis canadensis*, snare, Ontario.

Although age and sex structure of the harvest of Lynx (*Felis canadensis*) has been studied (Van Zyll de Jong 1963; Berrie 1971; Stewart 1973; Brand and Keith 1979), change in composition of the harvest during the trapping season is not documented. Also, the selectivity of traps used on Lynx has not been investigated. Such information could help wildlife biologists manage populations via the selective harvest of specific age-sex groups.

We studied the biology of Lynx in northern Ontario during 1979-1982. Objectives relevant to this paper were: 1) to determine if age and sex composition of the harvest of Lynx changes through the trapping season and 2) to determine if traps are selective relative to age or sex of Lynx.

Methods

Lynx carcasses were collected from trappers in 19 districts of the Ontario Ministry of Natural Resources in northern Ontario (Figure 1) during three trapping seasons (25 October-28 February) of 1979-1982. Data recorded on specimen tags included date and location of capture. The type of trap used (leghold or neck snare) was recorded during the third season.

Carcasses were dissected and age and sex were determined. Lynx in their first winter of life were classified as kits, those in their second winter were classified as yearlings, and Lynx older than yearlings were classified as adults. Kits were identified by incomplete closure of the basal foramen of canines (Saunders 1963). Age of older specimens was determined by counting cementum annuli. Sections fifty to ninety microns thick of the root tip of lower canines were decalcified in RDO (Dupage Kinetic Laboratories, Naperville, Illinois) and stained with haematoxylin. Annuli were counted under 150× magnification. Age was determined by adding 1 to the count of annuli since the first cementum annulus of Lynx is not deposited until late in the second winter of life (Nava 1970). Details of this technique are in Johnston and Watt (1980).

Results

Seven hundred and ninety-five carcasses were collected. Yearlings dominated the sample, particularly in fall and early winter, but their numbers tend to decrease with time; however, yearling males appeared again in large numbers in February (Figure 2). Kits of both sexes were relatively scarce but increased

FIGURE 1. Area from which Lynx carcasses were collected, Northern Ontario, 1979-82.

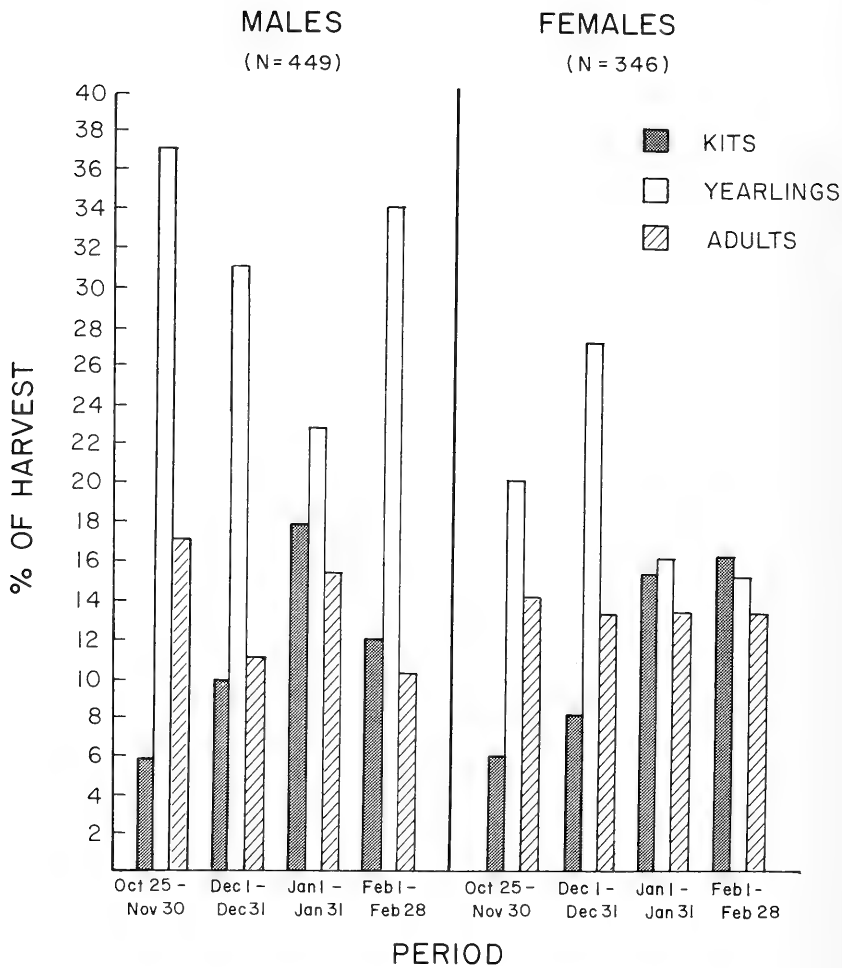

FIGURE 2. Age and sex composition of the harvest of Lynx over time, northern Ontario, 1979-82.

markedly in the harvest after December. Adults were a fairly constant component of the harvest (Figure 2).

Age distributions of Lynx caught in neck snares and leghold traps were similar (Table 1). Sex ratios, however, were quite disparate; the ratio of males to females was much higher in leghold traps than in snares (P = 0.08, Table 1). This latter result suggests differential vulnerability of the sexes to the two types of traps. Note, however, that yearling males accounted largely for the disparity of sex ratio.

Discussion

In summary, this study has shown that age and sex composition of the harvest of Lynx in Ontario changes markedly through the trapping season, and that male Lynx may be more vulnerable to leghold traps than females.

Several characteristics of the age and sex composition of the harvest of Lynx have been identified consistently, namely; a preponderance of yearlings, underrepresentation of kits, and predominance of males in the yearling and adult age classes (Van Zyll de Jong 1963; Berrie 1971; Stewart 1973; this study). These observations, and the results of this study, are due to age and sex-related differences in behaviour (Saunders 1963; Brand et al. 1976; Brand and Keith 1979; Mech 1980).

Lynx kits remain with females during the first winter of life until breeding begins in March and are at least partly dependent for food during that period (McCord and Cardoza 1982). The relative scarcity of kits in the harvest is probably due to this association (Brand and Keith 1979). The marked increase in occurrence of kits in January and February is proba-

TABLE 1. Age and sex distributions[1] of lynx caught in neck snares and leghold traps, northern Ontario, 1981-82.

	Neck Snare				Leghold			
Age	Male	Female	Unknown	Total	Male	Female	Unknown	Total
Kit	10	15	2	27	15	14	3	32
1	19	14		33	49	19		68
2	9	6		15	13	9		22
3+	1	1		2	4	5		9
Age Unknown	1	3	2	6	10	1	1	12
Total	40	39	4	83	91	48	4	143
Male:Female	1.25:1.00				2.24:1.00			

[1]For age distributions (sexes combined); $\chi^2 = 4.60$ $P > 0.10$, d.f. = 3
For sex ratios (Kits excluded); $\chi^2 = 2.90$ $P = 0.08$, d.f. = 1

bly due to their developing independence and the onset of dispersal.

The dominance of yearlings in the harvest, particularly in fall, probably reflected their occurrence in the population. Inexperience with traps, however, may also have been a factor. The resurgence of male yearlings in February may have been associated with the onset of breeding. Yearling males may have less fidelity to home range than adults, and as breeding season approaches, become restless and mobile and thus vulnerable to capture.

Male Lynx are thought to be more vulnerable to trapping because of greater home range and mobility than females (Saunders 1963; Mech 1980). The apparent differential vulnerability of the sexes to specific types of traps is difficult to account for. We have one hypothesis, and that relates to habitat selection. Snares must, to some extent, be set out in different habitat than leg hold traps because trappers in northern Ontario do not normally set snares for Lynx but fox (*Vulpes vulpes*) snaring is widespread. (Thus, most of the snared Lynx reported here were caught accidentally in fox sets). If Lynx segregate by age and sex into winter habitat an apparent "selectivity" of the two types of trap would result.

This study shows that age and sex structure of the harvest of Lynx could be influenced by manipulating the period of open season. Wildlife managers should be aware, however, that Lynx pelts are most prime in December and January (Stains 1979; A. Schief, personal communication). Also, this population was increasing rapidly (Quinn et al. in preparation) and the age structure of a declining Lynx population will be very different (Brand and Keith 1979). Composition of the harvest will change with phase of the Lynx cycle as well as seasonally.

Acknowledgments

We wish to thank the many trappers, conservation officers and biologists who contributed to the study. Jim Gardner was particularly helpful. Damien Joachim, Ian Watt and Colette Levangie assisted in ageing specimens.

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Received 26 July 1983
Accepted 17 September 1984

Range Extension to Quebec for *Protostrongylus boughtoni* (Nematoda: Metastrongyloidea)

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Department of Zoology, University of Alberta, Edmonton, Alberta T6G 2E9

Kralka, Robert A. 1985. Range extension to Quebec for *Protostrongylus boughtoni* (Nematoda: Metastrongyloidea). Canadian Field-Naturalist 99(2): 270.

Protostrongylus boughtoni was found in the lungs of each of ten Snowshoe Hares, *Lepus americanus*, collected near Saint-Sylvère, Quebec, in December 1982.

Key Words: *Protostrongylus boughtoni*, Snowshoe Hare, *Lepus americanus*, range extension, lungworm, Quebec.

Protostrongylus boughtoni, the nematode lungworm of Snowshoe Hares (*Lepus americanus*), has been reported from surveys in New Brunswick (Goble and Dougherty 1943), Ontario (MacLulich 1937), Manitoba (Boughton 1932) and Alberta (Cary and Keith 1979), as well as locations in the northern and central United States. There is little information available on the parasites of Snowshoe Hares of Quebec, and no published reports of *P. boughtoni* in particular. Hares from that province were examined in the present study.

Ten Snowshoe Hares were collected near Saint-Sylvère, Quebec (46° 14′N, 72° 13′W) on 30 and 31 December 1982. Lungs were removed, frozen and transported to the University of Alberta, Edmonton, where they were thawed and examined. Tracheae and bronchi were split open with forceps, and nematodes were located with the aid of a dissecting microcope. Nematodes recovered were fixed in cold glycerin-alcohol (5% glycerin in 70% EtOH) and examined as whole mounts after clearing in lactophenol solution.

Each of the ten sets of lungs contained adult nematodes identified as *P. boughtoni*. Mean intensity of infection was 16.4, with a range of 4 to 54 worms. Data on ages and sexes of the hosts were not available. Specimens of *P. boughtoni* from each hare were deposited in the University of Alberta Parasitology Collection, accession numbers UAPC 10796 to 10805.

P. boughtoni may cause considerable damage to lung tissue (Green and Schillinger 1935), but its potential role in Snowshoe Hare mortality has not been fully investigated. The lungworm parasitizes Snowshoe Hares throughout most of their Canadian range and extends into Quebec. However, Dodds (1960) examined approximately 600 Newfoundland Snowshoe Hares without reporting *P. boughtoni*.

Acknowledgments

I would like to thank Yves Leblanc for collecting the Snowshoe Hare lungs, and W. M. Samuel for initiating the project. T. M. Stock provided valuable comments on an early draft of the manuscript.

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Received 20 March 1984
Accepted 31 May 1984

News and Comment

Editor's Report for 1984: Volume 98

During 1984 the editing backlog was largely cleared away. The final three numbers of volume 97 (1983) were printed and mailed early in the year: (2) on 9 January, (3) on 6 March, (4) 9 April 1984. Volume 98(1) was mailed 31 July, (2) 13 November, (3) 14 December 1984 and (4) 29 January 1985. Editing for volume 99 is well advanced, with enough material to the printer for most of the volume.

The number of manuscripts submitted and accepted to 31 December 1984, compared with the years 1975–1983, is given in Table 1. The number of research manuscripts published in volume 98 by field of study is given in Table 2 and the distribution of book reviews and new titles is listed in Table 3.

Volume 98 contained 542 pages (see Table 4), surpassed only by volume 88(1974) which was 566 pages, but exceeding the two largest volumes, 90(1976) by 6 pages and 95(1981) by 26 pages. The latter volume contained the largest single issue, 95(3) 172 pages; in Volume 98 the largest issue was 98(1), 150 pages.

Included in Volume 98 were two more accounts of *The Biological Flora of Canada* series: 4. *Shepherdia argentia* (98(2): 231-244) and 5. *Delphininm glaucum* (98(3): 345-361). Dr. G. H. LaRoi, who has coordinated this series since its inception in 1979 (93(4): 415-430), has made a tremendous individual effort in circulating copies of submissions for review, corresponding with authors, and meticulous editing. Two additional contributions will appear in 1985.

A new series to provide edited published versions of

TABLE 1. Summary of manuscripts submitted and accepted by *The Canadian Field-Naturalist* 1975-1984.

Year Submitted	Number of manuscripts Submitted	Accepted	Per cent Accepted
1975	167	123	74
1976	147	93	63
1977	137	88	64
1978	149	93	62
1979	148	93	63
1980	137	89	64
1981	136	91	66
1982	138	97	70
1983	139	98	71
1984	130	54*	—

*Partial total only. An additional 40 manuscripts have been returned to authors for consideration of minor or major revision, and 20 were still with reviewers as of 31 December 1984.

TABLE 2. Numbers of new research and observation manuscripts published in *The Canadian Field-Naturalist* 98(1984) by major field of study.

Subject	Number of Manuscripts Total	(Articles + Notes)
Mammals	28	(13 + 15)
Birds	18	(11 + 7)
Amphibians and Reptiles	1	(0 + 1)
Fish	6	(2 + 4)
Invertebrates	1	(1 + 0)
Plants	18*	(11* + 7)
Total	72†	(38 + 34)

*includes two articles in the Biological Flora of Canada series.

†in addition there were 12 COSEWIC articles, one on the Committee as a whole, one on the Fish and Marine Mammals Subcommittee and 10 individual status reports (on fish) and two tribute articles (C. H. D. Clarke and R. W. Tufts) for a total of 86 manuscripts published.

TABLE 3. Numbers of book reviews and new titles published in the Book Review sections of volume 98 by topic.

	Reviews	New Titles
Zoology	30	140
Botany	11	38
Environment	6	68
Miscellaneous	2	37
Young Naturalists	0	32
Total	49	315

TABLE 4. Number of pages published in *The Canadian Field-Naturalist* 98(1984) by section (number of manuscripts in parenthesis).

	98 (1)	98 (2)	98 (3)	98 (4)	Total
Articles	44 (6)	80(14)	66 (8)	74(10)	264(38)
Notes	16(10)	16 (7)	14 (8)	20 (9)	66(34)
Biological Flora of Canada	—	14 (1)	17 (1)	—	31 (2)
News and Comment	2 (8)	4 (7)	3 (5)	4 (2)	13(22)
COSEWIC	71(12)	—	—	—	71(12)
Tribute and Bibliography	—	—	13 (1)	6 (1)	19 (2)
Report to Council	—	—	9 (1)	—	9 (1)
Advice to Contributors	1 (1)	1 (1)	1 (1)	1 (1)	4 (4)
Index	—	—	—	15 (1)	15 (1)
Book Reviews	16(14)	13(14)	13(11)	8(10)	50(49)
	150	128	136	128	542

Status Reports of species considered by The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was initiated with articles on the history and progress of the committee, its Fish and Marine Mammals Subcommittee, and 10 reports on rare, threatened, or endangered fish in Canada. Dr. R. R. Campbell has championed this effort and did the initial editing of the reports; the Department of Fisheries and Oceans provided publication support. One additional fish and six marine mammals will continue this series in 1985 and we hope to soon include some plants, amphibians and reptiles, birds and non-marine mammals in this series.

Dr. C. G. Van Zyll de Jong and Dr. W. O. Pruitt, Jr. (mammals), Dr. A. J. Erskine (birds), Dr. C. Jonkel (predator-prey relationships) Dr. D. E. McAllister (fish), Dr. S. M. Smith (insects), Dr. E. L. Bousfield (invertebrates) and Dr. C. D. Bird (plants) all continued to work actively as associate editors concerned with papers in their respective fields. Their efforts and those of outside reviewers chosen for individual papers provided the vital peer review which is the foundation of *The Canadian Field-Naturalist's* editorial policy. The following contributed reviews of one or more papers, mostly in 1984, but a few in 1983 who were inadvertently omitted from that years report (see 98(2): 261) because their contact had been directly with associate editors):
P. Achuff, P. Addison, S. Aiken, J. F. Aley, R. C. Anderson, C. D. Ankney, H. G. Baker, A. Bailey, G. Ball, J. Barlow, D. Barr, T. W. Barry, J. F. Bendell, A. T. Bergerud, S. Bleakney, D. A. Boag, J. Bogart, R. Boonstra, W. D. Bowen, E. Brodo, E. Broughton, D. F. Brunton, F. Bunnell, E. H. Burtt, R. Cameron, R. A. Campbell, S. Cannings, L. Carbyn, P. A. Catling, T. Cavender, R. Coupland, A. Ceska, L. N. Chlykowski, J. Christie, B. W. Coad, W. J. Cody, C. W. Crompton, E. J. Crossman, M. Dadswell, H. Dale, H. Danks, T. Diamond, R. J. Douglass, W. H. Drury, A. Dzubin, C. H. Ernst, W. N. Eschmeyer, D. Euler, L. Flanagan, P. Frank, B. Fenton, V. Geist, F. F. Gilbert, W. E. Godfrey, P. A. Gregory, G. W. Gullion, E. Haber, V. L. Harms, K. Hay, T. Herman, S. M. Herrero, L. V. Hills, P. W. Hicklin, O. Hohn, J. Hrapko, R. Ireland, R. James, L. Karstad, L. Keith, G. Kirkland, J. Kuijt, E. Kuyt, F. D. Lafontaine, D. M. Lehmkuhl, M. R. Lein, C. C. Lindsey, J. R. Longcore, H. Lumsden, W. J. Maher, R. MacCulloch, C. D. MacInnes, I. MacQuarrie, R. W. Mannan, A. M. Martel, J. A. Mathias, D. McAlpine, S. D. McDonald, R. McKelvey, I. A. McLaren, J. McNeill, M. K. McNicholl, J. D. McPhail, A. Middleton, J. S. Millar, R. R. Montanucci, C. C. Moore, D. W. Morris, W. Moser, P. Mousseau, D. Munro, J. O. Murie, T. M. Myers, D. Nagorsen, D. N. Nettleship, R. W. Nero, P. Nosko, M. Obbard, H. Ouellet, J. Packer, G. R. Parker, J. Pringle, M. Raine, M. Rau, P. Raven, W. L. Regelin, R. W. Risebrough, J. Rising, R. C. Rounds, J. S. Rowe, D. A. Russell, L. S. Russell, F. W. Schueler, B. Scott, G. Scotter, S. G. Sealy, D. Secoy, D. E. Sergeant, M. Shoesmith, N. R. Seymour, A. R. F. Sinclair, R. Singer, J. Smith, W. T. Smith, J. H. Soper, A. Stahevitch, K. W. Stewart, J. Svoboda, S. A. Temple, J. C. Underhill, N. A. M. Verbeck, K. Vermeer, F. J. L. Wagner, G. Watson, R. Wein, W. F. Weller, D. A. Welsh, D. V. Weselch, J. O. Whitaker, G. A. Wobeser, R. M. Youngman, R. Zach, S. Zoltai.

Special thanks are due to Dr. E. W. Eedy, Book Review Editor; W. H. Beck, who compiled the index to Volume 98, and to W. J. Cody, who serves in so many ways under the all-encompassing title of Business Manager. Barbara Stewart assisted throughout the year by processing and recording all incoming manuscripts, acknowledging and routing them. Louis L'Arrivée proof-read all galleys and Thérèse Lapierre typed the bulk of the correspondence. R. Mike Rankin of the Herpetology Section, NMNS provided liaison with the printer. A. W. L. Stewart provided special help with bibliographic sources. M. O. M. printed the journal, and Emil Holst and Eddie Finnigan made special efforts in a year when they were nearly swamped by the editor's efforts to get back on schedule.

The National Museum of Natural Sciences, National Museums of Canada, continued to assist the journal by allowing me partial space and time for it and I appreciate in particular the interest of Dr. H. Ouellet, C. G. Gruchy and Dr. A. Emery. Beyond the museum, Joyce Cook provided essential encouragement. Dr. R. E. Bedford and the members of the Publications Committee supported editorial efforts and decisions on behalf of the Council of the Ottawa Field-Naturalists' Club. Above all, my thanks are due to the authors who share our belief in the importance and relevance of *The Canadian Field-Naturalist* to the biological community of northern North America and to the variety of Ottawa Field-Naturalists' Club members and journal subscribers who together provide the broad independent financial base that makes publication possible.

FRANCIS R. COOK
Editor

Book Review Editor's Report, Volume 98 (1984)

This was one of the slowest years for the book review editor since 1978 when I began to keep records. Although the 315 new titles listed in the four issues of Volume 98 was close to the average for these seven years, it was much less than the 362 to 426 of the past three years and marks an end to a steadily increasing trend since 1979. The 63 new books received, 54 reviews completed, and 49 reviews published in Volume 98 are all, with one or two exceptions in earlier years, the lowest numbers in these categories.

The time required to catalogue, list and obtain reviewers for new titles is often considerable. For this reason, we greatly appreciate offers from both new and former reviewers. Suggestions of titles appropriate to *The Canadian Field-Naturalist* readers are appreciated, as well as offers to review books indicated as available in our New Titles. We can usually obtain complementary copies from publishers which are given to the reviewer in recognition of their effort.

Guidelines for reviews are available on request.

WILSON EEDY

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Call for nominations for Ottawa Field-Naturalists' Club Awards

Nominations are requested from Club members for the following awards:

- Honorary Membership
- Member of the Year Award
- Service Award
- Conservation Award
- Anne Hanes Natural History Award

Descriptions of these awards are given in *The Canadian Field-Naturalist* 96(3): 367 [1982].

With the exception of Honorary Members, all nominees must be members in good standing. Nominations and a supporting rationale should be submitted no later than 15 December 1985.

W. K. GUMMER

Chairman, Awards Committee
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Addenda to herpetological appointments at Canadian museums

In *The Canadian Field-Naturalist* 99(1): 119, Dr. Anthony P. Russell, Department of Biology, University of Calgary, was omitted from the Research Associates in herpetology with the Royal Ontario Museum, Toronto. My thanks to Dr. Bob Murphy for drawing this to my attention.

Dr. David Green, Research Associate with the Herpetology Section, National Museum of Natural Sciences, Ottawa, has moved from the University of Western Ontario to accept an appointment with the Department of Biology, University of Windsor, Windsor, Ontario N9B 3P4, as of 1 July 1985.

FRANCIS R. COOK
Editor

Book Reviews

ZOOLOGY

Vanishing Fishes of North America

By R. Dana Ono, James D. Williams, and Anne Wagner. 1983. Stone Wall Press, Washington, D.C. 257 pp., illus. U.S. $27.50.

Studying the part in depth may reveal the whole. So it is that a study of the endangered fishes of North America reveals the profound environmental changes that are sweeping across the United States and Canada. In five centuries accelerating waves man-made changes are modifying the environment. As far as the fish are concerned the most striking influences are consumption of water for agriculture, industry and cities and for hydroelectric power (resulting in reduced river flow, modification of seasonal flow and temperature regimes, drying of springs and blockage of migrations); changes in water quality (changes in turbidity, temperature, oxygen levels, salinity, and pollution levels); and changes in biota (exotics, food, parasites, competitors). At least one hundred and sixty-nine species and subspecies (153 species) in the United States have become threatened, endangered, or extinct due to these changes. This means that over one-fifth of the freshwater species of fishes in the United States are menaced (in Canada the proportion is less, so far).

This book is pleasingly and informatively written, with a text that is technically accurate but which can be read easily by the informed layman. A 2-page introduction by Dr. Sylvia Earle is followed by an all too short introductory chapter "The vanishing fishes." I would have liked to see a summary of the environmental changes in this chapter, with perhaps some general recommendations. Chapters III to XV deal with regions of North America or special environments, e.g. Atlantic and Gulf coast freshwater fishes; Great Lakes fishes; desert spring and pool fishes; western trouts, Texas blindcats and cavefishes, Tennessee and Cumberland fishes; and marine and estuarine fishes. This approach enables the author to discuss special regional problems. Thus, the threatened or endangered endemics of the Colorado River system are all affected by the dams, irrigation projects, urban demands, introduction of exotic species, and the "reclamation" schemes (= poisoning of "coarse" fishes). Following the general chapter introduction, the authors present examples of the species which are threatened or endangered.

The species accounts are not formatted. Instead the authors have summarized interesting facts of the life history, morphology, courtship, use of the species by natives, historical accounts from the explorers, and discuss changes in the distribution and population sizes, current threats, remedial plans, and occasional successes in restoring endangered populations. I've read numerous fish books and considerable literature on endangered species, but seldom encountered such fascinatingly written accounts. Some accounts are dramatic. The Devil's Hole Pupfish was threatened by wells which lowered the groundwater which supplied the spring. Department of the Interior officials tried to negotiate with the well drillers. Attempts to introduce them elsewhere failed. A plastic shelf and lights to provide vital algae were successful in a crucial period of low water levels. An Alaskan earthquake and subsequent three-foot wave nearly destroyed vital habitat. The U.S. Supreme Court ruled in favour of the pupfish, deciding the fate of an entire species for the first time in the court's history.

The successful application of the U.S. Endangered Species Act is related under several species accounts. That law is powerful and specific in its recommendations. There is no comparable set of laws in Canada specifically aimed at saving rare, threatened, and endangered species from extinction. COSEWIC (Committee on Status of Endangered Wildlife in Canada) unites federal and provincial government representatives with members of various wildlife groups to report on and classify the status of biota in Canada. However the status agreed on provides absolutely no protection in law. Governments wishing to avoid economic consequences may successfully downgrade proposed status. The recommendations for protection that were previously included in many reports have now been excluded, even though they were in no way binding.

Chapter XVI discusses 4 of the 21 North American species that have become extinct. Chapter XVII discusses the biogeography of menaced fishes — almost 80% of endangered species are confined to the southeast and southwest of the United States. Chapter XVIII deals with acid rain in only three pages and concludes with ". . . funding is juggled around with seemingly little commitment by governments, life continues to ebb from the lakes, streams, and ponds."

The last chapter, 2 pages long, tries to summarize the book without taking too gloomy a perspective and ends with a quotation from Henry David Thoreau: "In wildness is the preservation of the world."

An appendix lists threatened, endangered and extinct fishes of the United States (with some Canadian species), maps the ranges of the 44 species which are given accounts in the text, figures of the external anatomy of fishes, and provides a glossary of technical terms. References are provided on threatened and endangered fishes and selected books are listed for states and regions. Twenty-one conservation organizations are listed at the end. An index would have been useful.

Historical drawings, black-and-white photos, and 16 color plates embellish the book. An 1880 etching of Pyramid Lake is contrasted with a recent photo to show the drastic drop in water levels. A photo of a barren Tennessee dam landscape contrasts with a poetic description of the beauties of the river in 1834.

The book emphasizes throughout, the status, environmental, and historical problems of American species. However, two Canadian endemics and several species which range into Canada are discussed. No Canadian conservation organizations are listed. Nevertheless, the Canadian reader should be able to draw useful conclusions from the American experience. And Canadians should take warning that the serious shortage of water in the western United States may lead to increasing demands to draw on our water supply. Naturalists, anglers, conservationists, and persons working in fish and wildlife agencies on aquatic biota would benefit from having this book in their own library or that of their institution. We all can learn from this book that water is not a limitless resource. Its quality and flow, must be guarded by everyone. The authors and the editors are to be congratulated for producing a high quality, authoritative and very readable volume.

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Chironomidae of the Holarctic Region. Part 1. Larvae

Edited by Torgny Wiederholm. 1983. Entomologica Scandinavica Supplement No. 19. 457 pp. U.S $73.00.

Entomologica Scandinavica, well known as the publisher of a prestigious entomological journal, has undertaken the ambitious task in its Supplement series of producing, in three volumes, a set of keys and diagnoses to the genera of holarctic chironomids. The first of these, dealing with the larvae, has now appeared in a beautifully manufactured publication which should grace any library for years. The high quality of this publication, however, has been achieved at a hefty price (special price deals are available for the set and those interested should write to the publishers at their Editorial Office, Entomologica Scandinavica, P.O. Box 24, S-240 17, S. Sandby, Sweden).

This first volume is restricted primarily to larval keys and diagnoses, although the relatively short accounts for each genus also include brief notes on ecology and distribution (mainly in continental terms). The text includes only a perfunctory listing of the systematic history of each genus. Synonymies (a particularly severe problem in the Chironomidae) as a result are impossible to resolve from this reference alone and require that the reader also purchase Supplement No. 17 (*A Catalogue of Chironomid Genera and Subgenera of the World Including Synonyms* by P. Ashe, 1983) at an additional U.S. $15.00. Those already working with the older chironomid literature will find this Supplement a particularly useful guide.

The book does include a general introduction to larval morphology along with a basic guide to the terminology used in the rest of the text. While these are quite adequate for most purposes, there is some confusion in terms. For example, the terms clypeus and labral sclerite I are used interchangeably in the text, with no apparent mention of their being synonyms. Assistance is available here as well in the form of Supplement No. 14 (*Glossary of Chironomid Morphology Terminology* by O. A. Saether, 1980) at U.S. $13.60. This latter work is most useful in its attempts to standardize the terminology of earlier chironomid works to one common system. It is not required for use of the present volume on chironomids and is optional only.

The larval keys are primarily to genera, although in certain cases keys to some subgenera and species groups are included. The keys are generally easy to use, and most couplets rely upon distinguishing between reasonable morphological differences. They are of necessity complex due to the scope of coverage, which includes the entire holarctic region. In some cases, as for the Chironominae, this means additional work in preparing the specimens. Some problems may be encountered because of the heavy reliance in the keys on the S-setae. Since these setae may be obscured or difficult to see in all but the best slide preparations, identification attempts using these keys may sometimes be impossible.

Diagrams, so critical in publications of this kind, justifiably make up the major part of the book, comprising over 50% of the total number of pages. However, those familiar with some of the recent taxonomic works on chironomids will be disappointed with their quality. The high standards of other recent publications have been forsaken in favour of line drawings, and though generally clear, the diagrams in some cases can only be described as sketchy. This is particularly disappointing since the diagrams are all large and spaciously laid out.

Notwithstanding these criticisms, this volume and the subsequent ones on the Pupae and the Adults (assuming the same level of quality) will reign supreme as the basic reference works on chironomids. While intended as an identification guide, it serves to finally assemble in one place the most recent (to 1983, the year of publication — a feat in itself) taxonomic information. For most of those attempting to identify the chironomid fauna of this continent, this is the only source they are likely to need. Many years in the making, it appears well worth the wait.

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Communication and Behavior of Whales

Edited by Roger Paine. 1983. American Association for the Advancement of Science. Selected Symposium 76. Westview Press, Boulder, Colorado. xii + 643 pp. U.S. $35.00.

Whether perceived through the literary puissance of Herman Melville or the eerie humpback songs accompanied by Judy Collins, whales have long been a group much in the public eye. They are currently a major collision point for powerful economic interests operating amid insufficient international agreements, and their opponents including a diversity of conservationists and zoomystics. This volume reports the proceedings of a recent symposium on the behaviour of this topical group of mammals. The fourteen chapters are arranged into five parts. The first five chapters deal with vocalizations, the area for which the editor is justly famous. Investigations in humpbacks have revealed how singing patterns change within individuals and within seasons, and how aberrant songs give insight into the rules of song production. Two of the chapters deal with the social and behavioural contexts, and possible functions, of vocalizations in killer and right whales. The next four chapters examine the behaviour of several species on the breeding grounds (waters?), as well as attendant features on life history and population size. Particularly intriguing is the report on the aggressive use of callosities between males in right whales. Part 3 consists of two chapters on migrations and stocks of humpbacks, and the usefulness of songs in identifying both individuals and stocks. The two chapters of part 4 report techniques for discriminating the sexes and individuals in nature using morphological cues such as callosities. Part 5 is an annotated bibliography of the literature on humpback and right whales.

The emphasis on a biology of living whales, as opposed to one of carcasses, reflects the contemporary ethos of expanding animal rights. The findings on cultural changes in singing provide a fascinating glimpse into the rich world of these magnificent animals. Much of the material on communication, breeding, and migrations will interest workers in such areas as bird song and mating systems (e.g. the discussion of humpback songs within a phyletic framework of five evolutionary stages, and of dialects versus geographic variation in these songs). The methodological difficulties of classifying vocalizations, in whales and other species, continue to pose major tasks for researchers in communication. More critically, the book suffers from the general failing of symposium proceedings in terms of integration, tightness, and polish. Even as technical papers with necessarily much description, several of the chapters are excessively discussive. Interpretation of data, on group sizes and life history features, in terms of evolutionary theory would have strengthened the relevant chapters and broadened their readership. In such a thick book, it would not have required much space to include a taxonomic chart of at least the cetacean species discussed, the difficulties with right whales notwithstanding. Many of the chapter references would have been usefully merged with the bibliography. Overall, this volume is a solid, if imperfect, updating on the field.

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Fishes of Wisconsin

By George C. Becker. 1983. The University of Wisconsin Press, Madison. xii + 1052 pp., illus. U.S. $75.00.

State and provincial books on fishes vary from the deridable to the definitive. *Fishes of Wisconsin* falls in the latter category. It is an immense compendium of data on the 157 species found in this northern American state and is the product of 25 years of field work and an extensive review of the literature. Canadian waters share 126 of these species and the book is a valuable resource for Canadian ichthyologists.

Brief sections occupying 60 pages cover such topics as glacial history, water resources and uses, pollution, management, parasites, extirpated, endangered and exotic fishes, a glossary, abbreviations, and metric conversions. The index works well and is detailed. The references occupy 38 pages and number over 1700. About 35% of these date from the 1970s but the last year thoroughly surveyed for literature is 1977 and the number cited declines rapidly thereafter to only five in 1980. Identification keys occupy 108 pages and there are 24 pages of colour plates comprising 175 illustrations. The plates are rather disappointing in that some are photographs of live or freshly-caught fishes while others are of preserved material which has lost its colour.

The bulk of the text (783 pages) is species accounts comprising common and scientific names, a black and white photograph of each species, a description, systematic notes for about half the species, distribution, status and habitat, an account of the biology, and an importance and management section. Each species has a spot distribution map for Wisconsin and a general, shaded distribution map for North America. The Wisconsin maps summarise both Becker's modern collections and those prior to 1935 made by C. W. Greene, thus providing insight into changes in the state ichthyofauna. The biology section draws extensively on Becker's first-hand knowledge of Wisconsin fishes and is abundantly supplemented with citations from the literature and from personal communications encompassing all aspects of life history, behaviour, and ecology of the fishes. This is a valuable contribution which extends the utility of the work beyond the borders of Wisconsin. The photograph heading each species account is small and not always a good guide to the characters which distinguish that particular species. Line drawings would have served better in this capacity. There is no list of species and so no easy means of assessing the diversity of Wisconsin fishes.

Rather than nitpick at random through this tome, we have selected the family Petromyzontidae for critical comment. This family is not as familiar to most ichthyologists as the more diverse families which comprise the bulk of the text; arguably the job done here will reflect the quality of the rest of the book.

The section dealing with lampreys is 20 pages long, with an introduction to the family of two pages, and a 3-5 page coverage for each of the five species accounts. The species, in order of their appearance in the book, are: *Ichthyomyzon unicuspis, I. fossor, I. castaneus, Petromyzon marinus*, and *Lampetra appendix*. A more logical and appropriate order would have been an alphabetical arrangement of the species within a family. The key to lampreys is six pages long and is supplemented with drawings which are a great help in identification.

There are several inaccuracies in the key to the species which limit its usefulness. Both line drawings of ammocoetes on p. 77 do not show an eye although the outline of the eye is always clearly visible in an ammocoete even though it is covered with a more or less thick layer of skin. Lead 'a' of couplet 2 and the drawing below it call the larval oral hood a sucking disc which is a fallacy. The ammocoete filter feeds and does not suck. A hood-like sucking disk is therefore a misnomer. At metamorphosis, the oral hood becomes the dorsal and lateral parts of the sucking disc. The line drawing accompanying lead 'b' of couplet 2 is mislabelled. The "papillary fringe" is, in fact, the leathery appendages (also called oral fimbriae) which lie inside the oral papillae fringe. When Becker refers to the tongue precursor pigmentation and shape (pp. 78–79), he alludes only to the pigmentation and shape of the middle prong or bulb, which is only a part of the tongue precursor. In lead 'b' of couplet 3 and in the drawing above it, Becker writes that the base of the *P. marinus* "tongue precursor" is tapered. However, as is clearly shown in his drawing and in Vladykov (1950: figure 13), the base of the bulb flares out. There are three or four lateral rows of teeth in the line drawing of *I. castaneus* (p. 82), yet lead 'b' of couplet 7 states that the range is 6-10. The inclusion of ammocoetes in the key is an excellent idea as these are very difficult to identify. *Ichthyomyzon* ammocoetes were omitted but these can now be separated using the works of Vladykov and Kott (1980) and Lanteigne (1981).

The introduction to the family is excellent. Descriptive data on the fishes are mostly presented as ranges and it is not clear if the data are original or based on literature sources. If the counts and measurements are original, brief statistical information would have been useful for comparative purposes with populations elsewhere. The species descriptions introduce a new morphometric character "branchial diameter". Becker's ratio of branchial diameter to length of suck-

ing disc is innovative and useful in segregating the parasitic and nonparasitic species. Branchial diameter is poorly defined in the glossary (p. 52). It should be taken transversely as indicated in the diagram (p. 59) and not laterally. Becker cites for the maximum total length of *P. marinus* a report of a specimen of 915 mm and 1.36 kg (De Sylva, 1964). Oliva (1953), however, recorded a specimen of 1200 mm and 2.3 kg. On p. 206, "horizontal lingual lamina(e)" should read correctly "longitudinal lingual laminae". This type of unique character is not generally familiar to most biologists and is particularly susceptible to error, to the confusion of the reader. Vladykov (1960) is not credited with the description of peritoneal pigmentation in *P. marinus* and in *L. appendix* on pp. 211 and 216. The etymology for *L. appendix* on p. 216 is incomplete. The decline in Sea Lamprey numbers on p. 215 is given as 86% (from 71,081 to 9,992) but surely this should be a decline of 711%? Ammocoete lengths and weights should be included under the Description section of each species account as they are valuable diagnostic characters rather than under various other headings. Several other comments of this nature can be made on the species accounts. However these are all relatively minor and the accounts are very good.

These are 65 references on lampreys, the earliest in 1916 and the most recent in 1979. The reader is directed to Vladykov and Kott (1982) for an alternate view of the scientific name of the American Brook Lamprey (*Lethenteron wilderi* rather than *Lampetra appendix* as used by Becker).

The cost of this volume puts it beyond the reach of all but institutions and avid professionals although the price is reasonable for its size.

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A Dictionary of Ecology, Evolution, and Systematics

By R. J. Lincoln, G. A. Boxshall, and P. F. Clark. 1983. Cambridge University Press, New York, New Rochelle, Melbourne, Sydney. vii + 298 pp. cloth U.S. $52.50; paper U.S. $19.95.

There are more than half a dozen dictionaries of biology or zoology on my book shelves. None treat in any depth the fields of ecology, evolution and systematics (as I know from being the author of a manuscript dictionary of ichthyology of some 2000 terms), and most are outdated, omitting the neologisms of numerical and cladistic systematics. Inclusion of ecology, evolution and systematics together in one volume seems to me, as a systematist, to be natural; it is difficult to be a specialist in one of these fields without also having a knowledge of the other two.

The authors' goal has been to provide short working definitions of those terms that come within the routine reading matter of ecologists, taxonomists, and the like. They aim also to cover the application of statistics to ecology but have deliberately omitted basic anatomical terms. They opt for modern usage of terms except where usage has differed, in which case they chose the definition closest to the original or to the etymological derivation of the word or give divergent definitions. I estimate that about 11 000 terms are defined.

The short introduction is followed by 267 pages of definitions, alphabetically arranged. The remainder of the last page of entries for each letter of the alphabet is left blank. Following the dictionary are 21 appendices on the geological time scale, quaternary ice-age chronology (with European and North American periods), Wallace's zoogeographical regions (which will make some vicariance biogeographers spin on their plates), phytogeographical regions (from R. Good 1974), terrestrial biomes, major oceanic surface currents, marine and lacustrince depth zones, plankton size categories, taxonomic hierarchy, sediment particle size categories, soil profile and horizon nomenclature, SI units with some conversions to the

English system, temperature conversion chart, chemical elements, signs and symbols, acronyms and abbreviations, Latin abbreviations, Greek and Russian alphabets (with transliterations), proof correction marks (neither American National Standards Institute nor British Standards Institution marks), and the Beaufort wind scale. No references or sources are given.

Words being defined are in boldface while their definitions are given in ordinary type; this makes definition easy to find, unlike several dictionaries at hand. The definitions are usually given in simple clear English.

I tested the completeness of the dictionary by comparing it with the words in my own manuscript dictionary of ichthyology. Under the letters a to c, ignoring classes of words intentionally excluded, I found only six words lacking from Lincoln et al. (antitropical, aquatoria, biapocrisis, bitemperate, principle of continuity, and cystoarian). Since one goal of the dictionary was to give special attention to principles and processes, I applied a second test. This was to compare the principles in my own manuscript *Principles, rules and laws of natural history,* which I have been working on for about a decade, with those found in the dictionary (but excluding those in my manuscript outside of the stated domains of the dictionary). In my sections covering words beginning with a, b and c there were five entries not present in the dictionary (Rensch's rules of anagenesis, Benedict's surface area law, Buffon's law, the cicada principle, and Cabrera's rule). Of the 10 words beginning with a, b, or c in the glossary of the International Code of Zoological Nomenclature, one, *co-ordinate,* was missing. Other examples of omissions include *natural taxon, asexual species, Wagner analysis* and *tree.* Considering the number of disciplines that the dictionary must cover, its coverage is quite good.

It is important that the definitions in a dictionary be clear and correct. *Cotype* according to the International Code of Zoological Nomenclature was used in the sense of paratype or syntype; the dictionary does not mention the first meaning. Some words such as *littoral* that have been used in several ways in the literature, are given their several meanings. Others like *paraphyletic* that have been defined several times in recent literature (see E. O. Wiley. Phylogenetics. John Wiley & Sons, Toronto) are defined and characterized but once. *Species* is given a taxonomic and a rank definition, but not a biological (Mayrian) or an evolutionary definition under the species heading, but cross references are provided to these entries. *Key* is defined as a tabulation of character states facilitating identification; this might lead one to expect a table, rather than a series of couplets providing choices leading to (hopefully) the correct identification. Usually the definitions are clear and understandable even if they are not always in depth.

Generally cross references are adequate and enhance the usefulness of the dictionary. Thus, under polythetic the reader is referred also to monothetic. Few examples are given.

This is a very useful reference book. I would strongly recommend it for the use of students and professionals in ecology, evolution, and systematics.

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Breeding Birds of Ontario: Nidiology and Distribution. Volume 1: Nonpasserines

By George K. Peck and Ross D. James. 1983. Royal Ontario Museum Life Sciences Miscellaneous Publication. xii + 321 pp., illus. $20.00.

The present volume, the first of two to be published, presents nest record data for all of the nonpasserines (loons to woodpeckers) known to breed in Ontario up to 1980. In essence, this series will summarize all of the voluminous data (ca. 80 000 nest records) accumulated since the inception of the Ontario Nest Records Scheme (ONRS) in 1956, plus any historical records contained in egg and nest collections, as well as in serial and monographic publications. If one understands the limitations of the data base used to produce these books, then they will serve as an extremely valuable contribution to Ontario (and North American) ornithology.

An introductory section provides brief descriptions of the major biotic regions in Ontario (accompanied by a map), which should help readers to interpret and understand the distribution patterns exhibited by our birds. The section dealing with methodology will be of the utmost importance in the proper use of this book. A brief historical summary of Ontario nidiology is given, followed by a detailed explanation of the nature and use of the nest records in the ONRS. Examples of the way in which the data were analyzed and summarized are provided to enhance the reader's understanding of the species treatments that form the bulk of this book.

The species treatments (143 species covered in the first volume) provide a summary of the masses of data accumulated in the ONRS. Each species treatment includes the following information: number of nest records and their regional distribution (including a range map), habitat preferences, nest positioning, structure, and dimensions, clutch sizes and average clutch range, data on renesting and multiple nesting, incubation periods, and egg dates. In many cases, photographs of nests *in situ* or preferred habitats have been included in a section at the end of the book. The species treatments vary considerably in detail, depending on the distribution of the species and the ease with which the nest can be found. The types of data plotted on the breeding distribution maps are coded to indicate the type of evidence supporting each record. Records documented by photographs or specimens are coded differently than sight records. Historical records are also coded differently. This method of coding greatly enhances the value of the maps. In some cases, historical changes in distribution are revealed. The Common Loon, for example, is widely distributed throughout most of Ontario, but has disappeared as a breeding bird in the southwest. The Peregrine Falcon has virtually disappeared from all of its former eyries. The Bobwhite's breeding range has also diminished toward the southwest.

A few cautionary comments are necessary for users of this volume. One must always keep in mind that this book has been produced on the basis of data on nest record cards. This means that the distributions of some species, especially those in the relatively inaccessible portions of northern Ontario, will not be accurately reflected. Many species become very secretive during the nesting season, and these may also be under-represented in the ONRS. It is also important to realize that records of fledged young are not maintained in the scheme, and for this reason, a considerable amount of information probably remains in observers' notebooks, and was not available for inclusion in this book.

"Nidiology Volume 1", as this book has come to be known in Ontario, provides an important summary of historical information on the breeding birds of this province. Bearing the above cautions in mind, I think this work should serve as a cornerstone for future work on Ontario's birds. It should certainly serve as a basis of comparison for the Ontario Breeding Bird Atlas project (1981-1985), currently in progress. From a wider perspective, the amounts of information summarized herein should be very useful to all researchers studying any species known to breed in Ontario. This work should also stimulate further studies on the breeding biology of birds in the province, and hopefully, the production of such a book based on data provided by volunteers will encourage all field workers to continue (or begin) to submit their nest records to the ONRS.

The technical quality of production is good, although in several cases, due mainly to the format employed (breeding distribution map on the page facing the species treatment), considerable open (unused) space is evident. Very few typographical or mapping errors were detected, and although the book is a paperback, it seems to be very well bound and durable. The price is also very reasonable, and I recommend this book to all those interested in the breeding biology of Ontario's birds. I also look forward to seeing Volume 2, which will deal with the passerines.

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Breeding Birds of Long Point, Lake Erie: A study in community succession

By Jon D. McCracken, Michael S. W. Bradstreet, and Geoffrey L. Holroyd. 1982. Canadian Wildlife Service Report Series Number 44. 74 pp., illus. $11.75.

This interesting report discusses the results of a 16-year study of the breeding birds of Long Point, Ontario. During the study period, 40 breeding bird censuses were conducted in a variety of marsh and dune habitats ranging from cattail marsh to Red Oak-Sugar Maple forest. Forty-two species were found breeding in the marsh habitats while 48 were recorded in the dune habitats. Concurrent vegetation sampling allowed the identification of four marsh habitats, 14 dune habitats, and the successional relationships among them.

The data are used to compare bird abundance, density, and diversity among the habitats. The highest breeding densities (4312 territories/km^2) were found in cattail marsh while greatest diversity ($H = 2.78$) was found in wet woodland habitat. Changes in the bird communities due to vegetational succession were also discussed. In addition, an estimate of the total breeding bird population for Long Point is derived from the breeding bird densities in various habitats relative to the amounts of these habitats.

Following the discussion of the census results is a

very comprehensive annotated list of 115 breeding bird species that are known or presumed to have bred on Long Point. The list is based not only on the census results but also on all known historical information. Definite breeding evidence has been obtained for 98 species.

A noteworthy feature of this annotated list is that the breeding abundance codes (abundant, common, rare, etc.) are based on the actual densities of territorial males noted on the breeding bird censuses rather than the usually subjective judgements found in other such lists. In addition, density estimates obtained from the censuses are incorporated into the species accounts wherever possible.

The layout of this publication is generally appealing. There are many attractive photographs and figures placed appropriately in the text and there are few typographical errors. I did note that one photograph of a Tricolored Heron is incorrectly identified as a Great Blue Heron. One minor negative comment concerns the large amount of blank space left at the top of each page. As seems to be typical of this Canadian Wildlife Service report series, about 20 percent of the useable space on each page is left blank.

This publication will be useful to both biologists wishing to know about bird communities and succession in marsh and dune habitats as well as to naturalists or birders interested in the breeding birds of a unique natural area of Ontario.

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Waterfowl on a Pacific Estuary

By Barry Leach. 1982. Special publication No. 5, British Columbia Provincial Museum, Victoria. 210 pp., illus. $7.

The estuary dealt with in this book, by far the largest in British Columbia, is that of the Fraser River. But the subject matter goes well beyond the immediate estuary, current conditions there, or for that matter waterfowl. Geographic coverage spans the immensely varied wetlands from tidal foreshore inland to Chilliwack, and historical considerations stretch from geological formation of the Fraser Valley landscape to the present. Faunal subject matter includes the complex of wildlife species which depends directly or indirectly on wetland environments, with emphasis of course on geese and ducks.

This book possesses a rare blend of science and sentiment. While written in a vivid style that should be fully comprehensible to laymen, it contains over 200 literature citations and a 15-page index which give it lasting reference value. Embellishments include numerous black-and-white drawings by the author and thought-provoking quotations at the start of each of 24 chapters. Barry Leach has been a moving force behind establishment of waterfowl sanctuaries on the Fraser Delta and is well qualified to write on this subject.

The book is divided into four main sections. The first has an historical theme, documenting prehistoric factors which shaped Fraser Valley environments, pre-contact use of the region by native people, and the profound effects of European settlement. The effects of settlement on wetland habitats and direct impacts such as market hunting are pieced together, providing sound evidence that they resulted in drastic declines in waterfowl abundance and marked changes in seasonal or geographical patterns of occurrence. The historical theme, as noted by Yorke Edwards in his Foreward, is important because "The historical record rarely contains what most dismiss as only scenery and mere wild animals . . .". The second section provides life history accounts of the major waterfowl species or groups. This includes not only their abundance on and use of Fraser Delta lands, but insights into their activities on breeding grounds to the north and wintering areas to the south. The third section deals with specific habitats on the Fraser Delta which have been, or need to be, accorded sanctuary status, specifically Reifel Island Sanctuary, Serpentine Fen, Mud Bay, and the Pitt River Marshes. It concludes with a chapter on the successes, failures, and dangers involved in captive rearing and release of waterfowl, particularly geese. The final section of four chapters discusses contemporary problems facing the waterfowl — pollution, habitat loss, disease, predation, and human disturbance, and concludes with a thought-provoking assessment of future needs.

The author's main messages are that Fraser Valley waterfowl populations and habitats have diminished greatly in historic times; that some improvement has been realized in the past 20 years through establishment of sanctuaries and enhancement of habitat; and that additional sanctuaries are badly needed. He admits that habitat loss is the major threat to Fraser Delta waterfowl, yet appears to be rather more critical of the short-staffed and under-funded wildlife agencies which have fought to preserve habitat than of the municipal authorities, industrial establishment, and agricultural lobby which have usurped or degraded

habitat and continue to be a threat. That criticism evidently stems from the bias of government wildlife agencies, particularly the B.C. Fish and Wildlife Branch, in favor of hunters and hunting. Leach feels strongly that the proportion of estuary habitat in sanctuary status should be increased, and that open to hunting decreased.

Regarding style, I found the practice of placing several author references at the end of long paragraphs to be confusing because one cannot determine which statements or data are attributable to which authority. This defeats the purpose of providing references. More seriously, some paragraphs end with a statement of opinion by Leach, followed by an author reference in support of preceding information. This is inappropriate because the opinion statement could be attributed to the cited author. Typographical errors are very few.

Barry Leach writes with passion, sensitivity and authority about a subject dear to his heart. I highly recommend this book, not only to those interested in waterfowl ecology or Fraser Valley history, but as a stimulus to anyone involved in conservation projects. I commend the British Columbia Provincial Museum for maintaining the high quality of its Special Publication series.

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Bird Sounds and Their Meaning

By Rosemary Jellis. 1984. (1977). Cornell University Press, Ithaca. 256 pp., illus. U.S. $14.95.

The standing crop of bird watchers must exceed that of all other groups of zoophiles combined, and this is reflected in the large literature catering to them. The present work is the soft-cover edition of the 1977 hard-back original which was based on the BBC radio series. After a historically oriented Foreword by Fraser Darling, the book proceeds through various aspects of avian communication: the roles of sounds in bird behaviour and ecology, the structure of song and its spectrographic and temporal analysis, the ontogenetic and phylogenetic development of singing, dialects, individual recognition, imitations, and techniques for studying bird sounds. Appended is useful reference material on definitions, technical details, and bird societies and publications, as well as a bibliography and species index. The book is well illustrated with 90 figures, mostly sonagrams.

The intended audience is clearly amateurs. Personal reminiscences and anecdotes (frying bacon stimulates song in warblers) are presented in a chatty and affable style. The many species discussed are mostly from the British fauna, but this detracts very little for the North American reader. An agreeable amount of general ornithology and population ecology is woven into the text. One flaw is the use of invalid arguments based on the concept of group selection: for instance, "the species, then, is the unit on which the evolutionary processes are continually at work." Beyond this blemish, the author succeeds in conveying both scientific findings on, and candid enthusiasm for, singing birds.

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The Guinness Book of Animal Facts and Feats

By Gerald L. Wood. 1983. Third edition. Guinness Superlatives (Sterling, New York). 252 pp., illus. £8.95 (U.S. $19.95).

Records books doubtlessly imply something about fundamental human competitiveness. Here is the book for the zoological side of that trait The chapters proceed down the *Scala naturae* from mammals through lower vertebrates to invertebrate groups and prehistoric animals. The records given (both world and British) list not only standard categories such as largest, longest, and oldest, but also most intelligent, ferocious, and dangerous (!). Both metric and imperial units are given, highly appropriate for our semi-metricated world. The book is well referenced, indexed, and illustrated, including colour pages, and end paper charts providing velocity and longevity records.

The book stands in the long tradition of compilations of zoological facts dating back to the Roman Pliny. It is more a reference source than a volume to be read throughout, and contains no theory or interpretation on such underlying zoological issues as allometry or patterns of life histories. As title holder of smallest fish, future editions should report a goby from the Chagos Archipelogo described by Richard Winterbottom and Alan Emery of the Royal Ontario Museum in 1981. For lecturers wishing to spice their presentations, parents besieged by inquisitive offspring, and aficionados of Trivial Pursuit, the book will be valuable to have on hand.

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BOTANY

Where Have All the Wildflowers Gone?

By Robert H. Mohlenbrock. 1983. MacMillan Publishing, New York (Canadian distributor, Collier MacMillan, Toronto). xiv + 239 pp., illus. + plates. $22.95

This book has been written to bring the plight of rare and endangered American plants into the public forum. Because of Mohlenbrock's extensive experience in floristic and systematic research, he has been able to convey accurate information in the accounts of the 120 species covered in this book. At the same time, he has produced enjoyable and interesting accounts of these species. It is not necessary to have an extensive knowledge of botany to enjoy and understand the message being sent in this book.

The book has been divided into nine chapters and four appendices. Mohlenbrock has divided the U.S.A. into seven regions (northeast, southeast, north-central, south-central, Rocky Mountains, far west, and Hawaii-Alaska), and within each of these, he provides accounts of the endangered and threatened plants for which federal protective legislation is available. In total, 64 taxa have received official recognition in this manner. He also treats an additional 56 species which are either presently under review for inclusion on the federal list, or which he feels should be considered for inclusion. Each species account contains several interesting aspects. Wherever possible, the history of the taxon is outlined, including the general location and time of the original discovery of the plant, as well as the subsequent fate of those colonies. In many cases, Mohlenbrock has attempted to visit these sites, and anecdotal accounts of these visits convey his feeling of excitement at seeing these rare plants, and also his appreciation of the natural settings in which they occur. In certain instances, where the discovery of a rare plant has caused a controversy with regard to development proposals, etc., a brief history of the results of these controversies has also been given (see, for example, the discussion of Furbish's Lousewort, *Pedicularis furbishiae*, pp. 10–14). The graphic descriptions of the demise of numerous cacti through overcollecting for the greenhouse trade is also extremely instructive. In all cases, the rationale for inclusion on the federal list is given. I feel that this is an extremely important contribution for this book to make, since the general public often wonders how and why species are designated.

The chapters preceding and following the regional treatments give a good perspective to the entire book. The first chapter deals with *Thismia americana*, a native prairie plant that was discovered near Chicago in 1912, and has not been seen since 1914. This appears to be a case of extinction due to causes not induced by man. This chapter then also briefly summarizes the history of protective legislation for endangered organisms in the U.S.A. The closing chapter discusses other presumed cases of extinction, and issues a plea for involvement in local botanical organizations, and for protection of our native flora and the environment in general.

This book provides an extremely useful overview of the history and status of all of the U.S.A.'s officially recognized endangered and threatened plants. All of the species are dealt with in an interesting and informative way, and each is illustrated with a line drawing or a photograph. Most of these are of good quality, although the drawings tend to be small, and therefore lack floral detail. A few minor complaints about accuracy and detail come to mind, but these do not really detract from the value of this book. In most cases, Canadian distribution is briefly outlined, but in the case of *Isotria medeoloides* (Small Whorled Pogonia), no mention of the Ontario station is given. In the third appendix (plants presumed to be extinct in the U.S.A.), *Carex livida* is listed as not having been seen since 1922. However, a recent paper on the Carices of Minnesota (*Rhodora* 86: 151–231) shows it to occur in no less than 9 counties in that state, and it is also known from New England.

I have found this to be an enlightening and informative book that brings endangered and threatened plants into focus. The mandate for protection in Canada lies with the provinces, and I hope that the public servants entrusted with this responsibility here will take a lesson from the advances already made in the U.S.A. This is not to say that the Americans have completed their process of designation of species. It is an ongoing process, but the provinces of Canada have a long way to go to meet their obligations in this matter. With the publication of Mohlenbrock's book, the whole issue of protective legislation for endangered species is brought more fully into the public domain, both in the United States and in Canada.

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North American Terrestrial Orchids: Symposium II Proceedings and Lectures

Edited by E. H. Plaxton. 1983. Michigan Orchid Society, c/o Raymond McCullough, 14800 Harrison Avenue, Livonia. 143 pp., illus. U.S. $17.50.

Mention of the American Orchid Society (AOS) conjures up visions of colourful epiphytes growing in a tropical forest or in a greenhouse, scenes which a naturalist would not see in the field in Canada. While the image is justified, a look at the Bulletin or at the research funds of the AOS shows that they do not ignore the temperate terrestrial orchids. The present book is the proceedings of a symposium on North American Terrestrial Orchids at an AOS meeting in Detroit in October 1981 organized by the Michigan Orchid Society. The sessions lasted a day and a half and were well attended.

The ten papers review the North American terrestrials (NATS) with emphasis on culture, development, taxonomy, distribution, and conservation. They may be grouped into four categories for review purposes.

The first category deals with culture and development. C. T. Riley gives a brief summary of his methods of growing NATS from seed, in the hope that commercial growth will someday be possible. He also gives the formulation of his growth medium for seedlings. W. P. Stoutamire reports various observations on seedling development. Unfortunately, an interesting table of sizes of orchid seeds in the paper cannot be put to any quantitative use in the absence of the standard deviations of the averages. In the third paper in this group, C. E. Whitlow gives a general outline of his methods of cultivation of Cypripediums, and gives capsule comments on his experience with 19 species, both North American and Asiatic.

The second category has only one paper, that of R. T. Holman, in which he describes the application of a modern method of chemical analysis, gas chromatography, to the identification of the components of flower fragrances. He illustrates the use of this technique for studying the composition of odours from various parts of the Cypripediums as well as from *Platanthera obtusata* and then discusses the possible taxonomic value of such measurements in the Mexican Govenias. Holman uses an unusual quantity to measure the relation between species. This relation involves the concept of the minor ratio, i.e. the smaller quantity divided by the larger. But this is not mentioned in the present paper. His equation, however, is written in terms of normal ratios. His discussion is then confusing until the reader refers to a previous paper.

The third category deals with NATS in the Great Lakes region, mostly on the U.S. side. P. W. Thompson gives a brief outline of organizations protecting natural areas in Michigan and their holdings, which total 391 000 acres (158 000 ha). R. J. Griesbach and J. H. Asher Jr. present a wide-ranging review of NATS and their habitats in the Boundary Waters Canoe Area of Minnesota adjacent to Quetico Park. Much of the article is a literature review, for they comment that they have not seen and studied many of the NATS in the Boundary Waters Canoe Area. F. W. Case Jr. first updates his valuable, but out-of-print,

book with a concise report of new species (10!) for the Western Great Lakes. He then presents some thought-provoking ideas on orchid habitats, populations and conservation. His statement "the Mere Bleu, a vast spruce bog north of Ottawa" would read more accurately as "the Mer Bleue, a large (2 000 ha) raised bog east of Ottawa."

The final category of papers, presented on the second day, reviews NATS on a national basis. C. J. Sheviak discusses first the numbers of species to be found in the various vegetation zones of the 48 states, then the unresolved taxonomic problems of *Cypripedium calceolus*, and finally some speculations on NATS ecology, in particular the role of mycorrhizae and soil nutrients. E. W. Greenwood, a Canadian working in Mexico, reports on Mexican studies on NATS, pointing out the exploratory nature of the work and the taxonomic and other difficulties involved. His paper appears to be a much-condensed version of his lengthy talk and does not reflect the considerable emphasis he placed on the importance of column structure for orchid taxonomy. Perhaps of greatest interest to students of Canadian orchids is P. M. Catling's critical and well-documented review of the Canadian scene. In it, he reviews the vegetation zones of Canada and their orchids, taxonomic progress and problems, range extensions, and breeding systems. Among the tables and appendices is a table listing orchid taxa of Canada, Alaska, and Greenland. This table shows the known species, forms, varieties and hybrids in each province, with carefully-considered nomenclature and references. One form, *Calypso bulbosa* f. *candida*, which has been reported from British Columbia, is listed but with no localities indicated. It is not clear if this is an oversight or if Catling did not see a convincing collection. In spite of a puzzling distinction between records seen or not seen by the author, this table will be an invaluable reference on Canadian orchids.

Like many multi-author works, this one shows some inconsistencies. Thus, *Platanthera* is used in several papers, but *Habenaria* also appears, and *Cypripedium pubescens* can be found as well as *C. calceolus*. These usages should not cause much difficulty. A perhaps more serious problem is revealed in the two maps of the vegetation zones of Canada and the U.S., which clearly use quite different definitions of the boreal forest as shown in the Lake Superior region. Some typographic errors occur, but they are neither numerous nor serious.

A particularly impressive feature of the production is the high quality of the colour illustrations based on the speakers' slides, especially in view of the moderate price. It is unfortunate that the slides used by Catling were converted to black-and-white.

Anyone interested in the culture, distribution, taxonomy or ecology of North American terrestrial orchids will find interesting reading and useful reference material in this book.

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The Rare Vascular Plants of New Brunswick

By Harold R. Hinds. 1983. National Museum of Natural Sciences, Ottawa. Syllogeus 50. 56 pp. (English), 41 pp. (French). Free.

With this volume the National Museum of Natural Sciences' Rare and Endangered Plants Project sees the eighth provincial/territorial study put to press (not including the Northwest Territories report which was treated in a different manner) and is now a long way down the road to complete Canadian coverage. And it's a well done volume too.

Hinds begins his treatment with the standard introduction section of the Rare Plants series (*viz*, Methodology, Format, Distribution of Rare Plants, etc.) and covers these topics well. A full-page map illustrating county boundaries and waterways, as well as the major centres for rare plant distribution in New Brunswick, is very helpful. His discussions are quite complete and free of technical errors. A few spelling errors (*Gentionella* for *Gentianella* and Université Leval for Université Laval, for example) do creep in but these are minor and do not cause a loss in meaning.

The main body of the text is taken up with status descriptions of the 207 rare taxa of native vascular plants in New Brunswick in terms of their herbarium record, North American range, habitat, North American status, and miscellaneous other data. These are well done and appear to contain more additional data (in the Notes section) than in previous volumes. These useful notes include when and where (and by whom) last collections were made for particular rare taxa, notification of site disturbance (or destruction) at one or more locations and so on. By and large, the data are very up-to-date. For example, Ontario is included within the range of *Thelypteris simulata* where it was only found in 1982. Ontario Rare Plants Atlas data

from 1982 and 1983 are incorporated. There are a few errors (mostly of omission) but these are not especially important (e.g. *Platanthera flava* is no longer listed as Rare in Ontario; *Scirpus smithii* is best described as Rare in Canada; *Polygonella articulata* is not included on the Québec list of rare plants and thus may not be Rare in Canada).

A short but useful Excluded Plants list, that discusses rare species reported in other sources to be rare in New Brunswick but which are no longer considered to be so for various reasons, is appended to the report. This is important because it increases the credibility and clarity of the report by accounting for what otherwise would be seen as omissions. An appendix listing all of the taxa discussed in taxonomic sequence (the standard sequence of all previous Rare Plant studies but the Québec list) rounds out the text. Excellent maps that illustrate the distribution of each rare taxon within New Brunswick follow the English text. These maps are clear and precise and are a vital part of any such study.

One aspect of the study does, unfortunately, limit its usefulness somewhat. It is not clear how the author decided which were introduced rare taxa (and thus were to be deleted). *Puccinellia nuttalliana*, for example, is 'weedy' in parts of range (e.g. Ontario) and is common in parts of western Canada where Hinds says that it does not occur (*cf.* J. Looman and K. F. Best. 1979. Budd's Flora of the Canadian Prairie Provinces. Agriculture Canada, Ottawa). Similar uncertainties arise with such species as *Pycnanthemum virginianum, Polygonella articulata,* and *Chenopodium gigantospermum.*

The treatment of possibly introduced taxa is the only question I am left with in this fine study. It is otherwise a precise, concise and extremely useful addition to the rare plants literature of Canada and serves as a good model for subsequent volumes.

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Lichens of the Ottawa Region

By I. M. Brodo. 1981. Syllogeus 29. National Museum of Natural Sciences. Ottawa. 137 pp., illus. Free.

One problem experienced by people interested in Canadian lichens is a general lack of published lichen keys. The best that had been available for the Ottawa region (or almost any other part of Canada for that matter) was Mason E. Hale's *How to Know the Lichens*. Unfortunately, Hale's book treats Canada mostly as a peripheral region. As a result, the novice can be confused by the fact that many of the species are rarely (if ever) found in Canada and the distribution maps for Canada are often vague. More importantly, the crustose lichens are not, with a few exceptions, included in Hale's book.

Now, thanks to Irwin Brodo, we have a set of keys which include all lichen species known to occur within a 30 mile radius (50 km) of Ottawa.

Lichens of the Ottawa Region is actually a combination of three articles originally published in *Trail & Landscape* (Brodo 1967a, 1967b, 1972) and which many of us have used for a long time. Dr. Brodo has completely revised and combined these articles into one publication.

Lichens of the Ottawa Region opens with a brief introduction which includes a lichenological history of the Ottawa region, an explanation of how to use the identification keys, and methods of collection and study. This section could have been expanded to include more detail and to cover topics such as air pollution biomonitoring, lichenometry, lichen dyes, and edibility.

The first key, to genera of crustose lichens, is easy to use and quickly allows you to identify the genus of crustose lichens which have mature fruiting bodies. Further identification to the species level is done using a separate set of 26 species keys for crustose lichens. If no fruiting bodies are present, there is also a key to sterile crustose and squamulose species. There are some terms used in these keys which are not to be found in the glossary but they are usually self-explanatory (e.g., orbicular, esorediate). The major morphological features of lichens are illustrated in a page of figures following the glossary. The figures, which were drawn by Anne Hanes, Susan Laurie-Bourque, and Brenda Carter, are generally excellent. However, I do think that the labels used in Figures 65-74 should not have been abbreviated.

Keys for the foliose and fruticose lichen species allow the user to identify lichens directly to species without having to resort to separate generic keys. The interspersed black-and-white illustrations are extremely helpful.

Although the keys were prepared with the Ottawa region in mind, they are applicable for most of the Great Lakes – St. Lawrence Forest region. They will be less reliable in the Maritime region and west of the Great Lakes. I have employed the keys throughout Ontario. I found them helpful, although understan-

dably incomplete, for northern Ontario. As Dr. Brodo points out, "This edition (available in both French and English) is still, in a sense, an interim version because a great deal more exploration of the Ottawa region needs to be done . . .". Subsequent editions will no doubt incorporate additions and corrections submitted to Dr. Brodo by sharp-eyed purchasers of this book.

The 8½ × 11 inch spine-glued format is not at all field worthy. A smaller (5 × 7½ inch) format with steel or plastic coil binding would be a great improvement for the second edition. Species distribution maps and colour plates would also be useful.

Lichens of the Ottawa Region Syllogeus series No. 29 (English edition) is available from the National Museum of Natural Sciences, National Museums of Canada, Ottawa, Ontario, K1A 0M8. The French edition is available from the same address under the title *Lichens de la region d'Ottawa*.

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The Sedge Family (Cyperaceae)

By T. M. C. Taylor. 1983. Handbook No. 43. British Columbia Provincial Museum, Victoria (Manning Press). vi + 374 pp., illus., plus distribution maps.

The Sedge Family contains keys, descriptions and distribution maps for 165 species of Cyperaceae of British Columbia in a pocket-size format. It is intended specifically as an aid to identification of all sedges found in the province. Of the twenty-nine handbooks of this series which are still in print, this is the eighth dealing with vascular plants and, of these, six were written by the late Dr. T. M. C. Taylor.

The book is based on a study of specimens in four main herbaria (UBC,V,DAO,CAN) and the author leans heavily on the treatment of Cyperaceae by Arthur Cronquist in C. L. Hitchcock's *Vascular Plants of the Pacific Northwest* as well as on the subsequent one-volume *Flora of the Pacific Northwest*. The absolute necessity for a hand lens or magnifier (10× to 20×) or, preferably, a dissecting microscope, for identification is stressed as is the importance of specimens being both mature (with fully developed fruit) and complete, including the underground parts.

Following a brief introduction and a formal description of the family, there are keys to the eight genera found in the province, viz., *Carex* (130 species), *Cyperus* (1), *Dulichium* (1), *Eleocharis* (8), *Eriophorum* (8), *Kobresia* (2), *Rhynchospora* (1), and *Scirpus* (14). One other genus, *Hemicarpha*, has been excluded as the report was based on a misidentification. The genera are treated in alphabetical order and those with two or more species have an introductory key to species. Because of its large representation, *Carex* is handled in a different manner. The generic description is followed by a systematic list of species, keys to the sections (using the classical arrangement of K. K. Mackenzie's monograph), and then a series of keys to species within the sections. The sequence of species (numbered from 1 to 130) follows that of the sections, thus placing related species nearer to one another than in an alphabetical arrangement.

For each species the author has given the scientific name, a common name, a complete description, limited synonymy, a distribution map, an illustration, and notes on habitat, general range and provincial distribution. The descriptions and keys appear to have been carefully prepared, although this reviewer has not tested them. One discrepancy should be pointed out in that *Scirpus setaceus*, described and illustrated on page 356, has not been included in the key.

The illustrations are line drawings prepared by Ronald A. With and they are excellent. As pointed out by the author himself, the illustrations constitute a valuable contribution to the book. Without them it would be a much less useful tool for identification. Included for each species is a habit drawing and details of spikes and achenes and, in the case of *Carex*, also the perigynium, enlarged. However, it would have been helpful in the case of *Carex* to show also the subtending bract or scale beside the perigynium as the scales often furnish important characters used in the keys to species. Seven species lack an illustration and there appears to be no explanation for the omission, viz., five species of *Carex* and one each in *Eriophorum* and *Scirpus*.

At the end of the main section there is a discussion of twenty-five excluded species (21 in *Carex* and one each in *Cyperus, Eleocharis, Hemicarpha,* and *Scirpus*), a three-page glossary, a list of twenty-three references and the index. The excluded species are not listed in the index which is unfortunate. The note on *Carex vesicaria* on page 364 should have been indexed and also cross-referenced on page 279 where it appears as a partial synonym. The same problem occurs with two other species of *Carex* in the section on excluded species.

In order to evaluate the completeness of coverage, a comparison was made with the species of Cyperaceae reported in the recent inventory of the Vascular Plants of British Columbia (R. L. Taylor & B. MacBryde. 1977. U.B.C. Press). This computerized listing includes eleven species of Cyperaceae not found in the index of the present handbook. Such a discrepancy would appear to be significant but further checking revealed that eight of the "missing species" are actually included under other names. However, they cannot be found easily due to the omission of the relevant synonyms both from the text and the index. Three unresolved cases include two species of *Carex* reported by Taylor and MacBryde, i.e., *C. rugosperma* var. *intonsa* (native to B.C.) and *C. tribuloides* (adventive in B.C.). These two had previously been accepted by T. M. C. Taylor in his *Vascular Flora of British Columbia* (a Preliminary Check List. Department of Botany, U.B.C. May, 1966. 31 pp., unpublished) where they appeared on page 13 as *Carex intorsa* (sic!) and *C. tribuloides*. The third species, perhaps overlooked by Taylor, is *Eriophorum altaicum* Meinshausen var. *neogaeum* Raymond, with two localities cited for British Columbia by Raymond (Contributions of the Institute of Botany, University of Montreal 70: 103. 1957). There is only one case of a difference in taxonomic treatment at the generic level. Taylor and MacBryde remove three species of *Scirpus* to the genus *Trichophorum* while in the handbook they are left in the genus *Scirpus* (*S. cespitosus, S. hudsonianus* and *S. pumilus*).

A number of omissions and typographical errors were noted. On page 3 the illustration of parts of the flower lacks the identifying letters given in the legend below it and page references that should have been inserted in blanks on pages 1 and 6 were missed during proofreading. Incorrectly spelled scientific names that were noticed include: *Carex foenea* (p. 53), *Carex leporina* (p. 362), *Cyperus esculentus* (p. 364), and *Hemicarpha* (p. 365). One species of *Scirpus* appears first as *S. cespitosus* (p. 333) and later (p. 338, 373) as *S. caespitosus*. In the index two errors were noted on page 371: under *Carex* the specific name *atratiformis* should be in roman type (not italic) as it is an accepted name (not a synonym), and the page given for *atrosquama* should be 235, not 225.

In summary, this publication is a valuable addition to the series of handbooks issued by the B.C. Provincial Museum. It is encouraging to see another one of the large families of vascular plants completed, adding to the rapidly growing base of information from which a complete flora of the province may someday be synthesized. Anyone interested in sedges or working with the flora of British Columbia will want this attractive and useful handbook.

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MISCELLANEOUS

Evolution and Genetics of Life Histories

Edited by Hugh Dingle and Joseph P. Hegmann. 1982. Springer-Verlag, New York. xii + 250 pp. U.S. $33.80.

Goodbye Hardy-Weinberg, au revoir r and K, and welcome to the *real* world of life history evolution! In the preface to this book the editors promise the reader a "nourishing intellectual feast" but before most of us start salivating at the prospect of this smorgasbord we should acquire a few utensils — the geneticists would do well to read S. C. Stearns' review papers on life history traits and ecologists should dust off D. S. Falconer's classic textbook on quantitative genetics. Otherwise the messy world of additive genetic covariance structure may result in indigestion.

The book is based on a symposium held at the University of Iowa in October, 1980. Most of the papers are expanded and revised versions of those actually delivered at the conference; some have literature citations up to 1982. Nineteen authors contributed to the book in 12 chapters organized in five parts: theory, physiological adaptation, modes of reproduction, life history variation within populations and life history variation among populations. For each section the editors have provided a capsule preview and a candid 14-page discussion among symposium participants is included at the end of the book.

Istock leads off with a good discussion of the neo-Darwinian synthesis and the simplistic ecological and genetical models upon which it was based. He then develops a demographic model of age-specific selection. Lande continues the theory section with a dynamic theory of life history evolution using standard models of quantitative genetics and demography for populations with overlapping generations ("dynamic" is a buzzword found in several of the

chapters). Bradley then attempts to determine which models best account for the maintenance of genetic variance in temperature tolerance in a calanoid copepod. His experimental results suggest that most current models are unsuitable. Life history variability in the green lacewing species complex is examined by Tauber and Tauber. They conclude that the expression of genetic variation in these insects ranges from continuous variation to polymorphism and even complete asynchrony of life cycles.

In a long and rambling chapter Templeton critically focuses on the "prophecies of parthenogenesis" and claims that they, ". . . are grand sounding and certainly impart a profound reason for the evolution of parthenogenesis; but are these prophecies real, or, as in the case of Jesus, are there more mundane, less flashy explanations for the origin of parthenogenesis?" He then proceeds to test some of the major hypotheses with populations of *Drosophila mercatorum*, a species that normally reproduces sexually but whose females can reproduce parthenogenetically if isolated as virgins. Templeton concludes that the establishment of a parthenogenetic population from sexual ancestors is not an "event" but is a dynamic evolutionary process including many alterations in life history. The mind-boggling flow diagram summarizing this work could have been drawn more clearly.

Plants and vertebrates make only a token appearance in this book — single chapters by Schultz on competition and adaptation among clones of unisexual *Poeciliopsis* fish, and Meagher and Antonovics on life history differences between male and female *Chamaelirium luteum*, a dioecious forest floor herb. Both of these studies provide solid and interesting data but they are narrow in focus; little attempt is made to relate the findings to the more general questions raised at the symposium.

One of the most provocative papers is by King on the evolution of life span in a marine rotifer. In contrast to other workers who have treated death as an environmental event or an indirect result of selection for other features of reproduction, King argues that both senescence and life span are subject to natural selection. He proposes the hypothesis that in organisms with iteroparous reproduction life span should equal twice the generation time. King wisely emphasizes that we should remain skeptical about this generalization until experiments have been conducted on more taxonomic groups.

Doyle and Myers measured intensities of selection on life history traits in a laboratory population of the estuarine amphipod, *Gammarus lawrencianus*. They developed a methodology (path analysis) for dividing total selection into direct and indirect paths connecting the traits with fitness. Phenotypic correlations among life history traits were shown to have important effects on the intensity of selection. Hegmann and Dingle are also concerned with the problem of phenotypic and genetic correlation among life history characteristics. They examined the additive genetic variance-covariance structure of 11 characters in the milkweed bug, *Oncopeltus fasciatus*, from Iowa. Heritability estimates for all traits were large enough to predict that a response to selection could occur. The important point, however, is that changes in traits are not necessarily independent of each other, for example, directional selection for body size would also change developmental time. Surprisingly, age at first reproduction was not genetically correlated with any of the other life history variables.

Giesel, Murphy and Manlove compared the effects of temperature on the genetic organization of life history in three populations of *Drosophila melanogaster*. This paper has a good general literature review; it would have made a useful introduction to the entire book. In their experiments some evidence was found for the "trade-off paradigm", i.e., negative genetic correlations between indices of early life fitness and late life fitness, however, the picture was complicated by gentoype × environment interactions. Perhaps this study prompted Michael Rose (in the closing discussion) to comment that *D. melanogaster* is an "extremely badly behaved" experimental organism and, "If you vary or fail to control almost anything, experiments will not work."

In the final chapter, Dingle, Blau, Brown and Hegmann conduct a quantitative analysis of the relationship between genetic structure and phenotypic covariances in two species of milkweed bugs, *Oncopeltus fasciatus* and *Lygaeus kalmii*. They crossed widely separated populations of both species (Puerto Rico × Iowa for *Oncopeltus*, Colorado × Iowa for *Lygaeus*) to examine the disruption of coadapted gene complexes. Features of life histories were compared between parents, purebred lines and hybrids. The results ranged from no difference, to intermediate inheritance, heterosis, and even simple Mendelian segregation. This gave the authors a formidable task of interpretation, a feature common to several of the other experimental studies in this book. Dingle et al conclude that the traits have differentiated at dissimilar rates and that both genetic structure and the process of differentiation are dynamic.

This book is significant because it is the first serious attempt to bring together major workers in life history evolution research. As with most emerging disciplines there is much speculation and controversy. Nevertheless it is clear that real progress has been made in the relatively short time since Stearns' review of the subject in 1977. The editors will undoubtedly be satisfied

if the immediate impact of this work is an increased effort into measuring genetic variation of life history traits.

The book is not light reading and I recommend it mainly for the serious student of evolution. Naturalists may find certain chapters on a particular taxonomic group of special interest. I was disappointed that studies of birds and mammals were so conspicuously absent — this certainly cannot be attributed to a shortage of research effort on the life histories and quantitative genetics of these groups.

The book is well indexed and produced but a score of minor typos and omissions seems a bit excessive for Springer-Verlag. Dingle and Hegmann are to be commended for convening the symposium and editing this important steppingstone towards the next Darwinian synthesis.

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Recreational Land Use: Perspectives on its Evolution in Canada

Edited by Geoffrey Wall and John S. Marsh. 1982. Carleton University Press, Ottawa. 436 pp., illus. + maps. $14.95.

One of the more significant developments in Canadian life style over the past few decades has been an increasing emphasis on leisure, in particular recreational activity. Be it an annual canoe or back-packing trip, a weekend at the cottage, or even a day of bird watching in a provincial park, Canadians are interacting with the land in growing numbers. What is often overlooked, however, is that outdoor recreation is not a recent phenomenom but has a history dating back to the mid-nineteenth century.

Recreational Land Use, a new publication in the Carleton Library Series, is a collection of twenty-five essays that explore the diverse nature and evolution of recreation in Canada. Edited by university geographers Goeffrey Wall and John Marsh, the book attempts to offer through various examples some much needed perspective on this relatively new field of inquiry. It is a good start.

The papers that comprise *Recreational Land Use* have been divided into ten sections. After a brief introductory outline of some of the prevailing themes in outdoor recreation research, there is a keynote essay ("Changing Views of the Land as a Recreational Resource") in which co-editor Geoffrey Wall observes that Canadian attitudes towards the land and its recreation resources have altered dramatically over time. Areas once regarded as hostile environments, such as the Shield or Rockies, are now positively appreciated for their recreational potential.

This idea of changing attitudes runs through many of the subsequent papers. There is a one-essay section on pioneer recreation in Saskatchewan followed by two larger sections on the public and private provision of rural recreation. Specifically, John Marsh demonstrates in a revealing article ("The Evolution of Recreation in Glacier National Park, British Columbia, 1880 to present") how past practices and policies have left their mark on Glacier National Park. Equally interesting is J. G. Nelson's paper ("Canada's National Parks: Past, Present and Future") in which he argues that recreation, "once the hand maiden of protectionism," has become increasingly incompatible with wildlife preservation. Meanwhile, in another piece dealing with private ownership, ("The Development of Tourism in Nova Scotia"), C. A. Moffatt notes that flora and fauna are no longer simply exploitable resources but rather essential ingredients in the province's tourism industry.

The urban situation is covered by two lengthy sections on resorts and municipal facilities. One of the better articles ("Mowat and a Park Policy for Niagara Falls, 1873-1887") tells the fascinating story behind the creation of Ontario's first public park at Niagara Falls. The next grouping of essays deals with such topics as canoeing, camping and snowmobiling: Benedickson's contribution ("Paddling for Pleasure: Recreational Canoeing as a Canadian Way of Life) is noteworthy. These so-called activity histories are then followed by another one-essay section describing how historical artifacts have come to be regarded recreational resources in their own right ("Historical Artifacts as Recreation Resources"). The book closes with a somewhat provocative piece in which Wall suggests that the Canadian outdoor recreational experience, among other things, helps define the Canadian national identity.

What ties these various essays together is the recurring theme of evolution; the man-land relationship from the perspective of outdoor recreation is one of change and modification. This theme is most evident in the seven articles that Geoffrey Wall has contributed to the collection. Indeed, he continually raises a number of key factors that influence recreation development — namely, technological change, accessibility, fashion or tradition, work habits, population growth, role of government, and, most importantly,

the characteristics of the recreation resource itself. The next logical, though difficult, step is the writing of a history of outdoor recreational land use in Canada. Hopefully, Goeffrey Wall will take up the challenge.

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NEW TITLES

Zoology

The atlas of Africa's principal mammals. 1984. By Stephen James Smith. Natural History Books, Fourways, South Africa. 272 pp., illus. R39.50.

The Audubon Society handbook for butterfly watchers. 1984. By Robert Michael Pyle. Scribner, New York. xiv + 274 pp., illus. U. S. $17.95.

Avian biology, volume 7. 1983. Edited by Donald S. Farner, James R. King, and Kenneth C. Parkes. Academic Press, Orlando, Florida. xxiv + 542 pp., illus. U. S. $69.50.

The biology of butterflies. 1984. Edited by Richard I. Vane-Wright and Phillip R. Ackery. Academic Press, New York. 456 pp. U. S. $60.

†**Bumble bees of Saskatchewan (Hymenoptera: Apidae): a survey of their geographic distribution.** 1984. By Philip S. Curry. Natural History Contributions No. 5. Saskatchewan Museum of Natural History, Regina. 44 pp., illus.

Caste differentiation in social insects. 1984. Edited by J. S. L. Watson. Current Themes in Tropical Science, volume 3. Pergamon Press, Elmsford, New York. 400 pp., illus. U. S. $126.50.

†**Coastal waders and wildfowl in winter.** 1984. Edited by P. R. Evans, J. D. Cross-Custard, and W. G. Hale. Cambridge University Press, New York. x + 331 pp., illus. U. S. $54.50.

A field guide to the whales, porpoises, and seals of the Gulf of Maine and eastern Canada: Cape Cod to Newfoundland. 1983. By Steven K. Katona, Valerie Rough, and David T. Richardson. Third edition. Scribner's, New York. xv + 255 pp., illus. Cloth U. S. $22.95; paper U. S. $12.95.

***Flyways: pioneering waterfowl management in North America.** 1984. Edited by A. S. Hawkins, R. C. Hanson, H. K. Nelson, and H. M. Reeves. U. S. Fish and Wildlife Service, Washington. xix + 517 pp., illus.

Forest entomology: ecology and management. 1984. By Robert N. Coulson and John A. Witter. Wiley-Interscience, New York. xii + 669 pp., illus. U. S. $37.50.

†**Insect ecology.** 1984. By Peter W. Price. Second edition. Wiley, Somerset, New Jersey. xvi + 607 pp., illus. U. S. $37.50.

***Lizard ecology: studies of a model organism.** 1983. Edited by Raymond B. Huey, Eric R. Pianka, and Thomas W. Schoener. Harvard University Press, Cambridge. 501 pp., illus.

†**Milkweed butterflies: their cladistics and biology.** 1984. By P. R. Ackery and R. I. Vane-Wright. British Museum (Natural History) and Comstock (Cornell University Press), Ithaca, New York. ix + 425 pp., illus. U. S. $75.

†**Nest building and bird behavior.** 1984. By Nicholas E. Collias and Elsie C. Collias. Princeton University Press, Princeton. xix + 336 pp., illus. Cloth U. S. $45.; paper U. S. $16.50.

The pygmy chimpanzee: evolutionary biology and behavior. 1984. Edited by Randell L. Susman. Plenum, New York. c420 pp. U. S. $59.50.

***Scaling: why is animal size so important?** 1984. By Knut Schmidt-Nielsen. Cambridge University Press, New York. xi + 241 pp., illus. Cloth U. S. $29.95; paper U. S. $9.95.

The Sierra Club handbook of whales and dolphins. 1983. By Stephen Leatherwood and Randall R. Reeves. Sierra, San Francisco. xviii + 302 pp., illus. Cloth U. S. $25.; paper U. S. $12.95.

Spiders of the world. 1984. By Rod and Ken Preston-Mafham. Facts on File, New York. 191 pp., illus. U. S. $17.95.

The whistling hunters: field studies of the Asiatic wild dog (*Cuon alpinus*). 1984. By Michael W. Fox. State University of New York Press, Albany. viii + 150 pp., illus. Cloth U. S. $29.50; paper U. S. $9.95.

White-tailed deer: ecology and management. 1984. Edited by Lowell K. Halls. Stackpole Books, Harrisburg, Pennsylvania. 900 pp. U. S. $39.95.

†**Winter ecology of small mammals.** 1984. Edited by Joseph F. Merritt. Carnegie Museum of Natural History, Pittsburgh. 388 pp., illus. U. S. $45. plus U. S. $2.50 postage.

†**Wood warblers' world.** 1984. By Hal H. Harrison. Simon and Schuster, New York. 336 pp., illus. U. S. $19.95.

Botany

Air pollution and plant life. 1984. Edited by Michael Treshow. Wiley-Interscience, New York. xii + 486 pp., illus. U. S. $70.

***Atlantic wildflowers.** 1984. By D. Griffin. Oxford University Press, Toronto. 136 pp., illus. $19.50.

Biology of lichenized fungi. 1984. By James D. Lawrey. Praeger, New York. x + 408 pp., illus. U. S. $39.95.

The bitunicate Ascomycetes and their anamorphs. 1983. By A. Sivanesan. Cramer, Braunschweig, Germany. 700 pp., illus. DM200.

A checklist of the rare vascular plants of Alberta with maps. 1984. By John G. Parker and Cheryl E. Bradley. Provincial Museum of Alberta. Natural History Occasional Paper No. 5. Alberta Culture, Edmonton. 112 pp. Free.

Chloroplasts. 1984. By J. Kenneth Hoober. Plenum, New York. c280 pp. U. S. $42.50.

Ecology of tropical plants. 1984. By Margaret L. Vickery. Wiley, New York. viii + 170 pp., illus. U. S. $27.95.

Eutrophication and land use: Lake Dillon, California. 1984. By William M. Lewis, jr., et al. Springer-Verlag, New York. x + 203 pp., illus. U. S. $39.80.

Laboulbeniales (Fungi, Ascomycetes). 1984. By Isabelle T. Tavares. Cramer, Braunschweig, Germany. c700 pp., illus. + plates. DM150.

The lives of plants. 1983. By Doris M. Stone. Scribner's, New York. xvi + 304 pp., illus. U. S. $15.95.

Marine phytoplankton and productivity. 1984. Edited by O. Holm-Hansen, L. Bolis, and R. Gilles. From a symposium, Taormina, Sicily, September, 1983. Springer-Verlag, New York. viii + 175 pp., illus. U. S. $13.

Petunia. 1984. Edited by K. C. Sink. Springer-Verlag, New York. 288 pp., illus. U. S. $39.

The physiology of flowering plants: their growth and development. 1984. By H. E. Street and Helgi Opik. Third edition. Arnold, Baltimore. viii + 279 pp., illus. U. S. $18.95.

Plant life. 1983. By Mark Lambert. Warwick Press, New York. 93 pp., illus. U. S. $8.90.

Prodromus florae Hepaticarum Polynesiae. 1983. By H. A. Miller and B. A. Whittier. Bryophytorum Bibliotheca 25. Cramer, Braunschweig, Germany. 422 pp. DM150.

Weed ecology: implications for vegetation management. 1984. By Steven R. Radosevich and Jodie S. Holt. Wiley-Interscience, New York. xii + 265 pp., illus. U. S. $39.95.

Environment

The adventure of nature photography. 1983. By Tim Fitzharris. Hurtig, Edmonton. 216 pp., illus. Cloth $27.95; paper $19.95.

Adventures in wild Canada. 1984. By John and Janet Foster. McClelland and Stewart, Toronto. 160 pp., illus. $29.95.

Biological effects of organolead compounds. 1984. Edited by Philippe Grandjean. CRC Press, Boca Raton, Florida. 288 pp. U. S. $84. in U. S. A.; U. S. $97. elsewhere.

Biological oceanographic processes. 1984. By Timothy R. Parsons, Masayuki Takahashi, and Barry Hargrave. Third edition. Pergamon, New York. xii + 330 pp., illus. Cloth U. S. $40.; paper U. S. $19.75.

Biological processes and soil fertility. 1984. Edited by J. Tinsley and J. F. Darbyshire. Nijhoff/Junk, The Hague. U. S. Distributor Kluwer Boston, Hingham, Massachusetts. xxx + 403 pp., illus. U. S. $69.

Conservation, science, and society: the contributions of biosphere reserves to human welfare. 1984. Edited by Teffrey A. McNeely and Daniel Navid. UNESCO, Paris. vii + 573 pp.

Directory of environment statistics. 1983. By Department of International Economics and Social Affairs. United Nations, New York. vi + 305 pp. U. S. $30.

Ecological effects of fire in South African ecosystems. 1984. Edited by P. de V. Booysen and N. M. Tainton. Springer-Verlag, New York. xvi + 426 pp., illus. U. S. $33.50.

Ecosystems homeostasis. 1984. By Przemyslaw Trojan. Translated from Polish edition by Irina Bagaeva. Junk, The Hague. (U. S. distributor Kluwer Boston, Hingham, Massachusetts). viii + 132 pp., illus. U. S. $32.50.

†**Effects of pollutants at the ecosystem level.** 1984. Edited by Patrick J. Sheehan et al. SCOPE 22. Wiley, New York. xvi + 443 pp., illus. U. S. $59.95.

Fundamentals of air pollution. 1984. By Arthur C. Stern, Richard W. Boubel, Bruce Turner, and Donald L. Fox. Second edition. Academic Press, New York. 544 pp. U. S. $39.50.

Hazard assessment of chemicals: current developments, volume 3. 1984. Edited by Jitendra Saxena and Farley Fisher. Academic Press, New York. 488 pp. U. S. $65.

Land of bears and honey: a natural history of east Texas. 1984. By Joe C. Truett and Daniel W. Lay. University of Texas Press, Austin. xxii + 176 pp. U. S. $12.95.

Mathematical ecology. 1984. Edited by S. A. Levin and T. G. Hallam. From a course, Miramare-Trieste, Italy, November, 1982. Springer-Verlag, New York. xii + 513 pp., illus. U. S. $24.50.

†**Natural heritage of Manitoba: legacy of the ice age.** 1984. Edited by James T. Teller. Manitoba Museum of Man and Nature, Winnipeg. 207 pp., illus.

Resource management in the eastern slopes. 1983. Canadian Society of Environmental Biologists, Edmonton T6G 2E0. Proceedings of a symposium, Edmonton, 19 March 1983. 96 pp. $10.

Saltmarsh ecology. 1983. By S. P. Long and C. F. Mason. Blackie (distributed by Chapman and Hall, New York). viii + 160 pp., illus. Cloth U. S. $35.; paper U. S. $16.95.

Scanning nature. 1983. By D. Claugher. Cambridge University Press, New York. 115 pp., illus. U. S. $22.50.

Studies on tropical Andean ecosystems, volume 1: La Cordillera central Colombiana: transecto Parque los Nevados. 1983. Edited by Thomas van der Hammen, Alfonso Perez Preciado, and Polidoro Pintoe. Cramer, Braunschweig, Germany. 346 pp., illus. DM150.

Miscellaneous

†**Climate change in Canada 4: annotated bibliography of quaternary climate change in Canada.** 1984. Edited by C. R. Harington and G. Rice. Compiled by Anne B. Smithers, Linda Ghanime, and C. R. Harington. Syllogeus 51. National Museum of Natural Sciences, Ottawa. 368 pp. Free.

Directory of Canadian environmental experts. 1984. Fourth edition. By Environment Canada. Canadian Government Publishing Centre, Ottawa. $14. in Canada; $16.80 elsewhere.

†**Directory of marine and freshwater scientists in Canada.** 1984. Canadian Special Publication of Fisheries and Aquatic Sciences 73. Fisheries and Oceans Canada, Ottawa. 530 pp. Free.

Evolution: the history of an idea. 1984. By Peter J. Bowler. University of California Press, Berkeley. xiv + 412 pp., illus. Cloth U. S. $29.95; paper U. S. $10.95.

***Graduate research: a guide for students in the sciences.** 1984. By Robert V. Smith. I. S. I. Press, Philidelphia. xi + 182 pp., illus. Cloth U. S. $21.95; paper U. S. $14.95.

†**Weather almanac: a reference guide to weather, climate, and air quality in the United States and its key cities.** 1984. Edited by James A. Ruffner and Frank E. Blair. Gale Research, Detroit. viii + 812 pp., illus. U. S. $95.

Wild goose Jack: the life and work of Jack Miner. 1984. By James M. Linton and Calvin W. Moore. CBC Enterprises, Toronto. 208 pp., illus. $29.95.

Books for Young Naturalists

Giants of smaller worlds: drawn in their natural sizes. 1983. By Joyce Andy Dos Santos. Dodd, Mead, New York. 48 pp., illus. U. S. $12.95.

One day in the desert. 1983. By Jean Craighead George. Crowell, New York. 48 pp., illus. U. S. $9.95.

The Sesame Street question and answer book about animals. 1983. By Rae Paige. Western, Racine, Wisconsin. 45 pp., illus. U. S. $6.95.

Who knows this nose? 1983. By Marlene M. Robinson. Dodd, Mead, New York. 48 pp., illus. U. S. $10.95.

Wonders of zebras. 1983. By Vincent Scuro. Dodd, Mead, New York. 64 pp., illus. U. S. $9.95.

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Content

The Canadian Field-Naturalist is a medium for the publication of scientific papers by amateur and professional naturalists or field-biologists reporting observations and results of investigations in any field of natural history provided that they are original, significant, and relevant to Canada. All readers and other potential contributors are invited to submit for consideration their manuscripts meeting these criteria. For further information consult: A Publication Policy for the Ottawa Field-Naturalists' Club, 1983. *The Canadian Field-Naturalist* 97(2): 231-234.

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The **Council of Biology Editors Style Manual**, 4th edition (1978) available from the American Institute of Biological Sciences, is recommended as a guide to contributors. **Webster's New International Dictionary** and le **Grand Larousse Encyclopédique** are the authorities for spelling.

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Manuscripts submitted to *The Canadian Field-Naturalist* are normally sent for evaluation to an Associate Editor (who reviews it himself or asks another qualified person to do so), and at least one other reviewer, who is a specialist in the field, chosen by the Editor. Authors are encouraged to suggest names of suitable referees. Reviewers are asked to give a general appraisal of the manuscript followed by specific comments and constructive recommendations. Almost all manuscripts accepted for publication have undergone revision — sometimes extensive revision and reappraisal. The Editor makes the final decision on whether a manuscript is acceptable for publication, and in so doing aims to maintain the scientific quality and overall high standards of the journal.

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ISSN 0008-3350

The CANADIAN FIELD-NATURALIST

Published by THE OTTAWA FIELD-NATURALISTS' CLUB, Ottawa, Canada

Volume 99, Number 3

July-September 1985

The Canadian Field-Naturalist

The Canadian Field-Naturalist is published quarterly by The Ottawa Field-Naturalists' Club. Opinions and ideas expressed in this journal do not necessarily reflect those of The Ottawa Field-Naturalists' Club or any other agency.

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Back Numbers and Index

Most back numbers of this journal and its predecessors, *Transactions of The Ottawa Field-Naturalists' Club*, 1879-1886, and *The Ottawa Naturalist*, 1887-1919, and *Transactions of The Ottawa Field-Naturalists' Club and The Ottawa Naturalist — Index* compiled by John M. Gillett, may be purchased from the Business Manager.

Cover: Alpha Stream, Liard Hot Springs, British Columbia, 59°22′N, 126°03′W, showing the type locality for ***Physella wrighti*, new species**, described by George A. Te and Arthur H. Clarke (*see* pp. 295–299). The view is downstream and the photograph was taken 20 July 1979, the day the holotype (NMC 86709) was collected (courtesy A. H. Clarke, Ecosearch Inc.).

The Canadian Field-Naturalist

Volume 99, Number 3 July-September 1985

Physella (Physella) wrighti (Gastropoda: Physidae), A New Species of Tadpole Snail From Liard Hot Springs, British Columbia

GEORGE A. TE[1] and ARTHUR H. CLARKE[2]

[1]Museum of Zoology, University of Michigan, Ann Arbor, Michigan 48104
[2]Ecosearch, Inc., 325 East Bayview, Portland, Texas 78374

Te, George A., and Arthur H. Clarke. 1985. *Physella (Physella) wrighti* (Gastropoda: Physidae), a new species of tadpole snail from Liard Hot Springs, British Columbia. Canadian Field-Naturalist 99(3): 295–299.

Physella wrighti (new species) is known only from a 34 m reach of one warm stream in Liard Hot Springs Provincial Park in northern British Columbia. Evidence from cladistic and phenetic analyses, using many conchological and anatomical character states, shows that *P. wrighti* is a relict member of a primitive group which gave rise to the present major taxonomic groups in the subfamily Physinae. These data indicate that *P. wrighti* must have survived at that site at least since interglacial time and supports the conclusion of Prest that the region was not glaciated during Wisconsin-stage glaciation. This area, previously called Liard Tropical Valley because of its disjunct temperate vegetation, supports a diverse relict biota and it should continue to be maintained as a biological preserve.

Key Words: *Physella wrighti,* new species, Liard Hot Springs, interglacial relict.

During 1972 and 1973 A. H. Clarke, with the assistance of Brian T. Kidd in 1972 and the late Dr. David G. S. Wright in 1973, carried out a survey of the freshwater mollusks of British Columbia (Clarke 1974) for the National Museum of Natural Sciences, National Museums of Canada. Soon thereafter G. A. Te studied the numerous lots of Physidae (Tadpole Snails) which they had collected and he discovered that specimens from Liard Hot Springs represented an undescribed species (Te 1978). In 1979, in company with biologists from the British Columbia Hydro and Power Authority, Clarke searched Liard Hot Springs in more detail and, through access by helicopter, he also searched for molluscs in other isolated hot springs in northern British Columbia and southern Yukon Territory. Ecological observations were recorded, additional molluscs were collected, and more specimens of the new physid were retrieved and kept alive for further study.

We believe that this new species is significant both on evolutionary and on zoogeographic grounds. We also consider it desirable to call attention to it now because its population is so restricted and its ecological tolerances are apparently so limited that it could easily become extinct. In addition, Liard Hot Springs, sometimes referred to as "Liard Tropical Valley", is an important relict area for numerous temperate species of plants (Porsild and Crum 1959). We hope that the present paper will contribute to the continued preservation of the unique biological community which occurs there.

Physella wrighti (new species)
Liard Hot Springs Physa
(Figures 1a-1e)

DESCRIPTION: The shell is narrowly elongate-ovate and very small, adults averaging only 3½–4 whorls and about 5.5 mm in length. The protoconch is rounded, conical, and of the same color as the rest of the shell or slightly darker. The spire is long and acute and the penultimate whorl, and in some specimens the pre-penultimate whorl, is exerted. The body whorl is dominant and in some specimens it is slightly shouldered. The sutures are deep in most specimens and very deep in some. The columella fold is slightly to distinctly thickened, oblique, and in most specimens it is not twisted. A palatal callus is either not present or is only a thin whitish wash and not a thickening. A parietal callus is present in most specimens; it is narrow and thin adapically but quite broad near the columellar fold where it appears as a distinct layer. The aperture is acute above, somewhat flattened laterally, and narrowly rounded basally. The shell is regular in thickness, generally opaque, and does not exhibit any growth-rest thickenings. Collabral lines

are oblique and clearly visible but are not unusually coarse or fine. Spiral striations are absent or are few and scattered. The shell is light horn to yellowish horn in color and the surface is somehwat shiny but not glossy.

The body of the animal is dark in color with a black mantle which is generally without the circular patterns common to many physids. The mantle border has a short skirt which is about half as long as the distance between the mantle edge groove and the submarginal line. Pigmentation of the mantle border terminates above the submarginal line. Mantle digits are spade-shaped, number about six and are on the columellar side only.

The digestive tract is partially pigmented and the gizzard is laterally lobed, as in most other *Physella* species. The renal complex is rather broadly curved and ranges from being entirely tubular to more or less lamellar in internal structure. The bursa copulatrix is small in size and appears rectangular in shape. It lies on a horizontal axis with a duct attached to the side. The penial complex has a medium-sized to small, rounded, and loosely-packed preputial gland. The penial sheath is two-parted: the part proximal to the preputium is short, glandular, and slightly swollen and the distal part is non-glandular, non-turgid, and has a transparent membrane enclosing a tube-like penis. In general the glandular segment is shorter than the non-glandular segment and the whole penis sheath is about 1½ times the length of the preputium. The juncture between the glandular and non-glandular segments of the penial sheath is not particularly constricted.

COMPARISONS WITH OTHER SPECIES: In shell shape *P. wrighti* most closely resembles *Physella (Physella) virginea* (Gould, 1847) but that species, in addition to having a shell which is much more voluminous and more than twice as long, has a penial sheath with a heavily swollen glandular segment which is ¾ the length of the entire penial sheath. In *P. wrighti* the glandular segment is less than ½ the length of the penial sheath. In shell size, in its generally slender profile and in other shell characters *P. wrighti* also resembles *Physella spelunca* (Turner & Clench, 1974), *Physella virgata* morph *parva* (Lea, 1864), and *Physa skinneri* Taylor, 1954. *P. spelunca* and *P. virgata* morph *parva* can be distinguished from *P. wrighti* by their completely non-glandular penial sheaths, however, and *P. skinneri* can be distinguished by the fact that its penial sheath is completely bulbous and glandular.

The shells of *P. wrighti* are also similar to those of *Physella (Physella) hordacea* (Lea, 1864); *Physella (Physella) propinqua nuttalli* morph *triticea* (Lea, 1856), and *Physella (Costatella) cubensis peninsulae* (Pilsbry, 1899). In *P. hordacea* and *P. p. nuttalli* morph *triticea* the glandular segment of the penial sheath is much longer than the non-glandular segment whereas in *P. wrighti* the opposite condition prevails. *P. hordacea* and *P. p. nuttalli* morph *triticea* also differ from *P. wrighti* in several shell features, e.g. in general shape (elliptical, not elongate-ovate), aperture outline (loop-shaped rather than aurate) and spire morphology (dome-like with shallow sutures, not elongate-acute with deep sutures). In *P. c. peninsulae* the non-glandular portion of the penial sheath is highly muscularized and turgid whereas in *P. wrighti* it is sack-like and non-turgid. The penis in *P. c. peninsulae* is also muscularized and of large diameter but in *P. wrighti* it is a slender tube. In addition, *P. c. peninsulae* is a member of a subtropical species complex restricted to the Floridian and Caribbean region. For further details see Te (1978); in that work *P. wrighti* is discussed as OTU - 82.

TYPES: The holotype (NMC 86709) and numerous paratypes and topotypes are in the National Museum of Natural Sciences, National Museums of Canada, Ottawa. Other paratypes are in the National Museum of Natural History, Smithsonian Institution, Washington. The holotype and paratypes were collected at the type locality on 20 July 1979 and the topotypes were collected there on 19 August 1973. Measurements of some type specimens are given below. For measurements of additional shell characters see Te (1978) under OTU-82.

MEASUREMENTS	Length (mm)	Width (mm)	Approx. No. of Whorls
Paratype	6.1	3.0	4
Paratype	5.5	3.1	3½
Holotype	5.3	2.8	4
Paratype	5.1	2.9	3½
Paratype	5.0	2.8	3½
Paratype	2.8	1.8	2½
Paratype	2.7	1.5	3

The type locality is a short reach of Alpha Stream, in Liard Hot Springs Provincial Park, about 216 km WNW of Fort Nelson, in northern British Columbia. The reach extends from the mouth of Fern Creek (which enters Alpha Stream about 25 m below Alpha Pool) downstream for 34 m. The site is located at 59°22′N, 126°03′W, and is about 1 km N of Mile 496.5 of the Alaska (or Alcan) Highway and about 2½ km N of the Alaska Highway bridge over the Liard River. The location of Alpha Pool is shown by the lowermost "x" symbol on the map in the excellent paper by

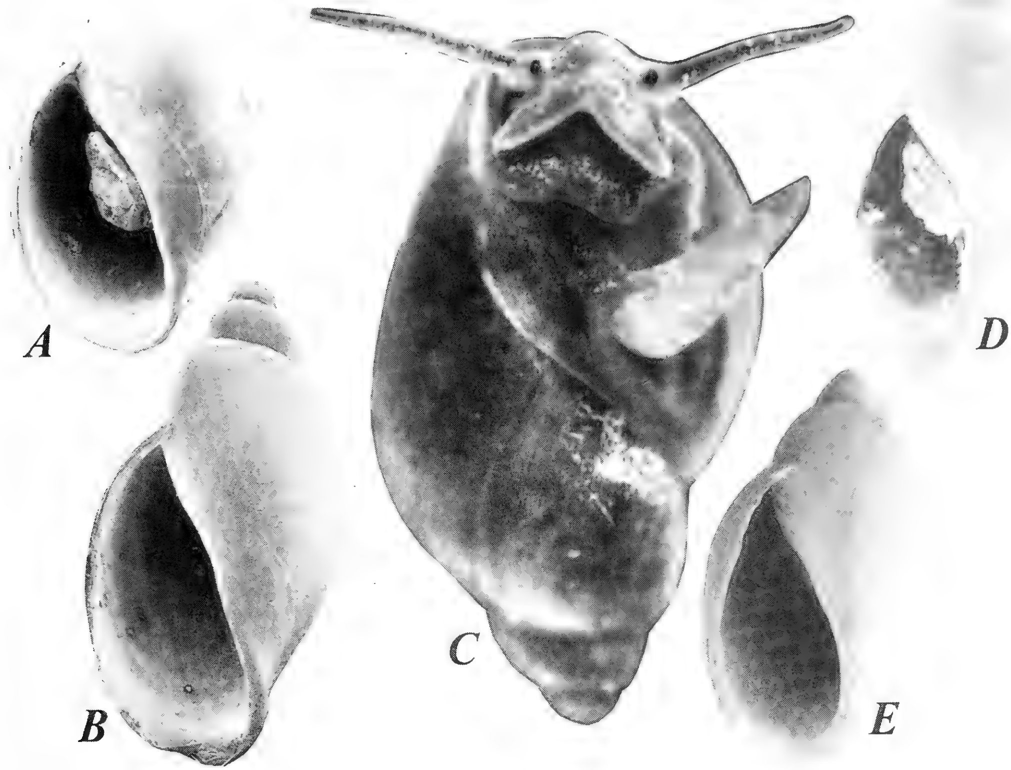

FIGURE 1. *Physella (Physella) wrighti*, new species. A, B, D, and E are SEM photographs of the holotype (B) and paratypes. C is of living specimen. Shell lengths are: A, 2.8 mm; B, 5.3; C, unmeasured; D, 2.7; and E, 5.1.

Porsild and Crum (1959) which should be consulted for information about the physiography and botany of Liard Hot Springs.

ECOLOGY: The whole population of *Physella wrighti* was found in Alpha Stream, the warm outlet of Alpha Pool, in an area beginning just below the mouth of a cool tributary, Fern Creek, and extending down-stream for 34 m. On 20 July 1979 the water in Alpha Pool was at 40° C, the water in Fern Creek was at 19° C, and the mixed water below the mouth of Fern Creek was at 23° C. Farther down-stream in other parts of Alpha Stream inhabited by *P. wrighti* water temperatures ranged up to 35° C. The snails occurred only on *Chara* plants at depths of 0.05 to 0.2 m and no other species of mollusks were present.

All of the shells of *P. wrighti* were densely covered with diatoms. The dominant species were tentatively identified, from SEM photographs, as *Cocconeis placentula* Ehrenberg and *Eunota pectinalis* (Dillworth) Rabenhorst var. *minor* (Kutzing) Rabenhorst.

Analysis of Alpha Stream water from just below the mouth of Fern Creek gave the following results: pH, 7.9; alkalinity (mg/L $CaCO_3$), 155; hardness (as mg/L $CaCO_3$), 660; suspended solids (mg/L), < 1.0; dissolved solids (mg/L), 1100; conductivity, (μmhos/cm), 1310; dissolved Ca (mg/L), 210; and dissolved SO_4, (mg/L) 330.

DISCUSSION: Although the shell characters and anatomical features of *P. wrighti* show greater concordance with those typical of the genus *Physella* (Haldeman, 1842), subgenus *Physella,* than with any other subgenus and the species is therefore considered a *Physella* (s. str.), *P. wrighti* has features which indicate a relationship with other subgenera as well.

For example, in the subgenus *Physella* (s. str.), *P. wrighti* and *P. virginea* are the only species with narrow, elongate-ovate shells, elongate-acute spires, ear-shaped apertures, and strongly-incised sutures. These character states are typical of the section *Alampetista*

(Zilch, 1956) of the subgenus *Costatella* (Dall, 1870), genus *Physella.* Although the anatomy of *P. virginea* places that species unequivocally in the subgenus *Physella,* the anatomy of *P. wrighti* has character states which link it both to *Physella* (s. str.) and to *Costatella* (s. str.). For example, the ratio of penial sheath length to preputium length in *P. wrighti* is less than 2.0 (actually about 1.5), and the glandular segment of the penial sheath is shorter than the non-glandular segment. Both of these character states are in agreement with *Costatella* (s. str.) but not with *Physella* (s. str.). The bursa copulatrix in *P. wrighti* is rectangular and is oriented horizontally, however, and this and a preponderance of other anatomical character states links *P. wrighti* with *Physella* (s. str.). When shell and anatomical characters are combined for phenetic analysis the results are similar to those derived from anatomical characters alone (see Te 1978 for details). Phenetic analysis also demonstrates that at a somewhat lower level of similarity *P. wrighti* is also related to the subgenus *Petrophysa* (Pilsbry, 1926).

A cladistic analysis of relationships within the Physidae (see Te 1978) supports conclusions based on the phenetic analysis. *P. wrighti* was found to branch out near the base of the *Physella* (s. str.) stem. In fact it was so low on the stem as to be close to the point where 4 of the 5 major groups of the subfamily Physinae begin to diverge, i.e. it is close to *Physella (Physella) microstriata* (Chamberlain and Berry, 1930), *Physella (Petrophysa) zionis* (Pilsbry, 1926), and the main stem leading to the subgenus *Costatella* with its two branches, the section *Alampetista* and the section *Costatella* (s. str.).

Conclusions

Several other warm springs and outlet streams, in addition to Alpha Stream in Liard Hot Springs Provincial Park, were also visited in 1979 in an effort to locate more populations of *Physella wrighti.* These were Grayling Springs (59°37′N, 125°32′W, and 59°37′N, 125°38′W), Deer River Hot Springs (59°30′15″N, 125°57′15″W), and Toad Springs (58°55′30″N, 125°05′30″W), all in northern British Columbia; Coal River Hot Springs (60°09′N, 127°09′W) in southern Yukon Territory; and other springs and pools in Liard Hot Springs Provincial Park, viz. Beta Pool, Gamma Spring, Epsilon Spring, Hanging Gardens Spring, and Alpha Marsh. A few other gastropod species were found but *Physella wrighti* occurred only in the outlet of Alpha Pool in the type locality.

Evidence from phenetic and cladistic studies cited above shows that *P. wrighti* is probably a relict member of the primitive group which gave rise to the present major taxonomic groups in the Subfamily Physinae. It also appears to be restricted to a single short reach of one warm-water stream in Liard Hot Springs Provinical Park, British Columbia. Further, its isolated geographical position in northwestern Canada suggests a proximate relationship with Pleistocene migration routes between Asia and North America (see Clarke and Harington 1978).

According to Prest (1970:701,754), stratigraphic data indicate that during Wisconsin-stage glaciation in the Pleistocene, the Cordilleran and Keewatin ice sheets made contact in only a few places in the region of the Liard Plains and the Liard Plateau, and parts of that area were unglaciated. This is the region in which Liard Hot Springs is located. Biological evidence provided by the presence of *Physella wrighti* strongly supports the conclusion that Liard Hot Springs, at least, was not glaciated at that time. *P. wrighti* is certainly a primitive species not closely related to any other species in northwestern North America and it is virtually impossible that it could have evolved as such a distinct species since the end of the Pleistocene. It therefore must have survived at that locality at least during Wisconsin-stage glaciation (i.e. since about 100 000 years ago) and Liard Hot Springs must have escaped glaciation during at least that part of the Pleistocene. Such a conclusion also raises the possibility that some of the temperate plants which at Liard Hot Springs occur far north of their major distributional areas (Porsild and Crum 1959) may also be relicts from some interglacial or preglacial period and not disjunct remnants of more continuous northern distributions which may have occurred during a warm climatic interval within the past 7000 years.

Clearly *P. wrighti* is of special relevance to studies in molluscan evolution and zoogeography. Its small, relict, and potentially endangered population should be carefully protected. For this and other reasons Liard Hot Springs should be conscientiously maintained as a biological preserve.

Acknowledgments

We wish to dedicate this new species to Dr. David G. S. Wright, whose untimely death in 1975, shortly after his graduation from the University of British Columbia, cut short a promising career in Canadian biology. Dr. Wright, a friend and colleague, was the co-collector of the original specimens of this new species. Valuable field assistance in 1979 was also given by Messrs. Paul St. Pierre, Douglas Rowland, and Adolf Ceska. We also thank the late Dr. Joseph Rosewater of the Smithsonian Institution and Mrs. M. F. I. Smith of the National Museums of Canada for recently providing access to specimens under their care, Dr. Greta A. Fryxell of Texas A & M University for diatom identifications, and Dr. Klaus Ruetzler of

the Smithsonian Institution for photographs of living specimens of this new species. SEM photographs were by Mr. Edward Sellick of Harvard University and Ms. Mary Jacque Mann of the Smithsonian Institution. The work was supported by the National Museums of Canada, the Smithsonian Institution, the University of Michigan, the British Columbia Hydro and Power Authority, and ECOSEARCH, Inc.

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Received 16 March 1984
Accepted 19 November 1984

Notes on the Occurrence, Ecology and Identification of the Massachusetts Fern, *Thelypteris simulata*, in Ontario

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Catling, Paul M. 1985. Notes on the occurrence, ecology and identification of the Massachusetts Fern, *Thelypteris simulata*, in Ontario. Canadian Field-Naturalist 99(3): 300–307.

Thelypteris simulata (Davenp.) Nieuwl. is reported for the first time in the province of Ontario. Two stations were discovered, both in eastern Ontario and both in Red Maple bog-fringe forests with a herb layer dominated by robust plants of *Osmunda cinnamomea*. The pH of the decomposing leaf litter substrate ranged from 3.8 to 4.3. *Thelypteris simulata* is one of several vascular plants with an eastern North American distribution pattern, that is confined in Ontario to the far eastern area bounded by the lower Ottawa and St. Lawrence Rivers. Useful diagnostic characters in addition to non-dividing veins are glands on the undersurface of the leaves, and long-acuminate pinnae tapered to the base.

Key Words: Massachusetts Fern, *Thelypteris simulata*, Ontario, taxonomy, phytogeography, ecology, distribution, new record.

A few immature fern fronds were collected during an early summer field trip to Alfred Bog. These fragments were collected in order to determine whether or not they were referable to the Massachusetts Fern (*Thelypteris simulata* (Davenp.) Nieuwl.). This Atlantic coastal plain species is known in Canada from Nova Scotia and single stations in Queens Co., New Brunswick, and south of Clarenceville, in the eastern townships of Quebec. The latter station is approximately 140 km ESE of Alfred Bog. Although reported from Stormont Co., Ontario by Dore and Gillett (1955; repeated by Scoggan 1978), Massachusetts Fern was not included in part 2 of the Atlas of the Rare Vascular Plants of Ontario (Dickson et al 1983) since the report was based on a misidentified specimen of New York Fern (*Thelypteris noveboracensis* (L.) Nieuwl., *Gillett 7969*, DAO 379958). Examination of the immature material from Alfred Bog suggested that it was referable to Massachusetts Fern. This prompted a more extensive field survey and an evaluation of diagnostic characters.

Methods

A field survey was conducted throughout eastern Ontario in June 1983. This included the careful searching of appropriate habitats and documentation of discoveries through notes and preparation of herbarium specimens including dried plants or photographs, or both, deposited in herbarium collections (DAO, TRTE, OAC, MICH, -acronyms from Holmgren et al. 1981). A variety of bog and swamp habitats in eastern Ontario were surveyed including moist acid woods on sand to NE and WNW of Casselman and appropriate wooded habitat in all bog areas over 100 acres in extent.

In order to evaluate diagnostic characters, specimens of Massachusetts Fern and Marsh Fern (*T. palustris* Schott) from throughout their areas of distribution were examined (at CAN, DAO and MICH). Frond silhouettes were prepared using the xerox technique and pinnule characters were drawn using a camera lucida.

Results and Discussion

Habitat

A survey of the Alfred Bog station in late June when the plants were fully grown revealed five patches of Massachusetts Fern. The two largest of these were approximately 10 m² and contained several hundred fronds. The other patches were 2 m² and contained 40–50 fronds. The rooting medium of the ferns was composed entirely of decomposing leaf litter with a pH of 3.8–4.3. All patches occurred within an area of three acres in a forest dominated by Red Maple (*Acer rubrum*) to approximately 20 m tall with average d.b.h. of 16 cm and canopy 70% closed. Eastern White Cedar (*Thuja occidentalis*), Balsam Fir (*Abies balsamea*) and Gray Birch (*Betula populifolia*) were scattered through the forest. Sparse thickets of Winterberry (*Ilex verticillata*) and Chokeberry (*Aronia melanocarpa*) were present also. The herb layer was dominated by a dense cover of Cinnamon Fern (*Osmunda cinnamomea*) with Goldthread (*Coptis trifolia*), Clintonia (*Clintonia borealis*) and Bristly Clubmoss (*Lycopodium annotinum*). Also present were Wood-Sorrel (*Oxalis montana*), Wild Lily-of-the-valley (*Maianthemum canadense*), Wild Sarsaparilla (*Aralia nudicaulis*), Bunchberry (*Cornus canadensis*), Starflower (*Trientalis borealis*), Royal Fern (*Osmunda regalis*), Painted Trillium (*Trillium undul-*

FIGURE 1. Habitat of Massachusetts Fern in Newington Bog, Stormont Co., Ontario.

atum), Whorled Wood Aster (*Aster acuminatus*), Northern Dewberry (*Rubus hispidus*), Red Maple seedlings (*Acer rubrum*), Ground Pine (*Lycopodium dendroideum*) and Indian Cucumber-root (*Medeola virginiana*).

The second eastern Ontario station, in Newington Bog (Figure 1), approximately 44 km SW of Alfred Bog was discovered in a remarkably similar plant association. The Newington colony, approximately 2 m^2 in extent, contained approximately 100 fronds. It was similarly in a Red Maple bog-fringe forest with the herb layer dominated by Cinnamon Fern. The canopy was 70% closed and the trees to approximately 20 m tall and 15-20 cm d.b.h. Eastern White Cedar and Paper Birch (*Betula papyrifera*) were also present and of similar size. Sparse thickets of Winterberry and Chokeberry occurred in more open places. Co-dominant (with Cinnamon Fern) in the herb layer were Goldthread, Clintonia and Wild Lily-of-the-valley. Marsh Fern, Royal Fern, Wild Sarsaparilla, Skunk Currant (*Ribes glandulosum*), and Bristly Clubmoss were also present. The pH of the decomposing leaf litter substrate was 4.0.

These eastern Ontario stations of Massachusetts Fern are similar in most plant associates to the Wisconsin stations reported by Hartley (1965) and Moran (1980). However, sphagnum moss is often present at these stations in the driftless area (Moran 1980; Peck 1982) and other authors (*e.g.* Wherry 1961; Tryon and Tryon 1973) have described the habitat generally as wet, peaty situations with sphagnum. In direct contrast to these wet sites, Moran (1980) has recently described a sandstone rock crevice habitat in Wisconsin. He notes a number of cases of bog plants on cliffs and further notes an equivalent condition of drought, and substrate reaction and nutrient composition. Thus the relatively dry substrates, lacking sphagnum, at the two Ontario stations is not unexpected. Roland and Smith (1969) note that in Nova Scotia, Massachusetts Fern grows in "situations too shady for the Marsh Fern and too wet for the New York Fern". At the Ontario sites it occurs in more shaded and more dry conditions than the Marsh Fern. New York Fern was not present in the immediate vicinity.

Distribution and Phytogeography

Tryon and Tryon (1973) show a relatively restricted distribution for Massachusetts Fern in North America. Since Hartley's (1965) discovery in the driftless area of Wisconsin, 12 additional stations have been found in that region (Moran 1980; Peck 1982). Moran (1981) reports a major extension of known range to eastern Tennessee. In Canada, Massachusetts Fern has been previously found only in the provinces of Nova Scotia (Roland and Smith 1969; Tryon and Tryon 1973) New Brunswick (Hinds 1981, 1983) and Quebec (Rousseau 1974, p. 48). The Clarenceville (Missisquoi Co.) station is still the only one known in Quebec (Rousseau 1974) and consequently it is listed as rare in the province (Bouchard et al. 1983). The North American distribution of Massachusetts Fern, including the Quebec, New Brunswick and Tennessee stations, which were not previously mapped (Tryon and Tryon 1973) is shown in Figure 2. New Ontario stations are shown more accurately in Figure 3.

Massachusetts Fern is one of several vascular plant species with an eastern North American distribution pattern, and is confined in Ontario to the far eastern section bounded by the Ottawa and St. Lawrence Rivers. Other plants in this category are Atlantic Sedge (*Carex atlantica* spp. *capillacea*), Toothed Umbrella-Sedge (*Cyperus dentatus*), Large Purple Fringed-Orchid (*Platanthera grandiflora*), Rhodora (*Rhododendron canadense*), and Downy Goldenrod (*Solidago puberula*). Other eastern species, including Whorled Wood Aster (*Aster acuminatus*) and Gray Birch (*Betula populifolia*), occur commonly in far eastern Ontario but sparingly westward.

Some of these eastern species are northeastern, while others are found primarily on the Atlantic coastal plain from Nova Scotia southward. Massachusetts Fern is in the latter category and both Raymond (1950, pp. 78, 117) and Rousseau (1974, p. 48) have listed it among the coastal plain elements present in Quebec.

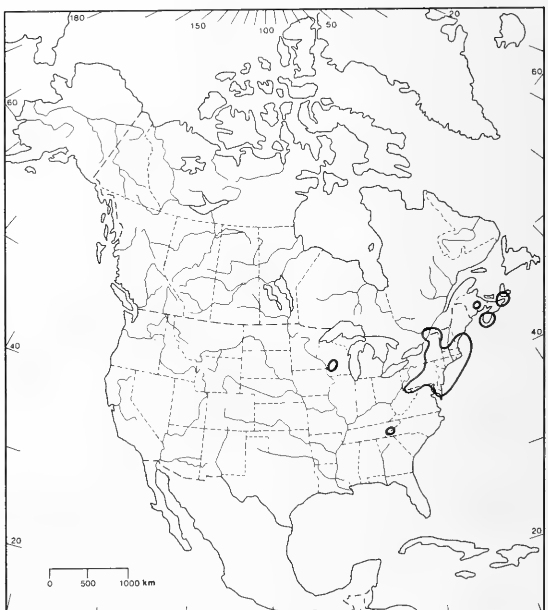


FIGURE 2. Distribution of Massachusetts Fern in North America (after Hartley 1965; Tryon and Tryon 1973; Moran 1981; Hinds 1983)

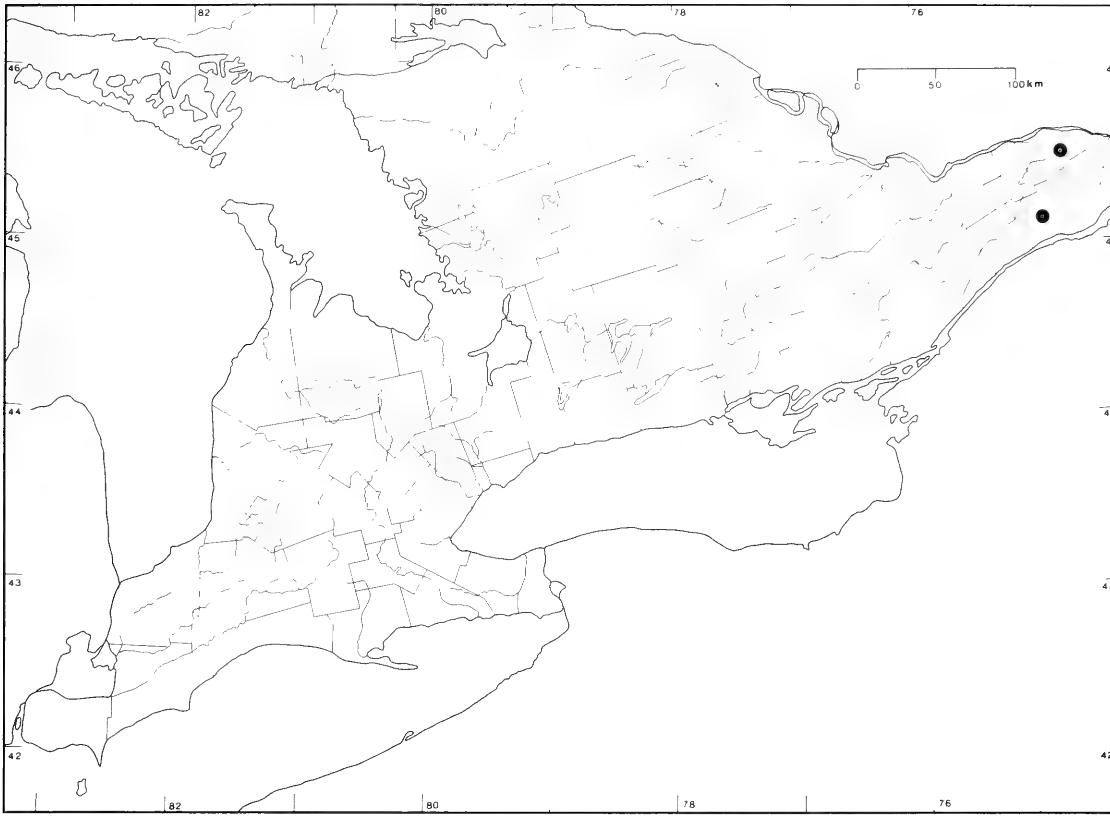


FIGURE 3. Distribution of Massachusetts Fern in Ontario.

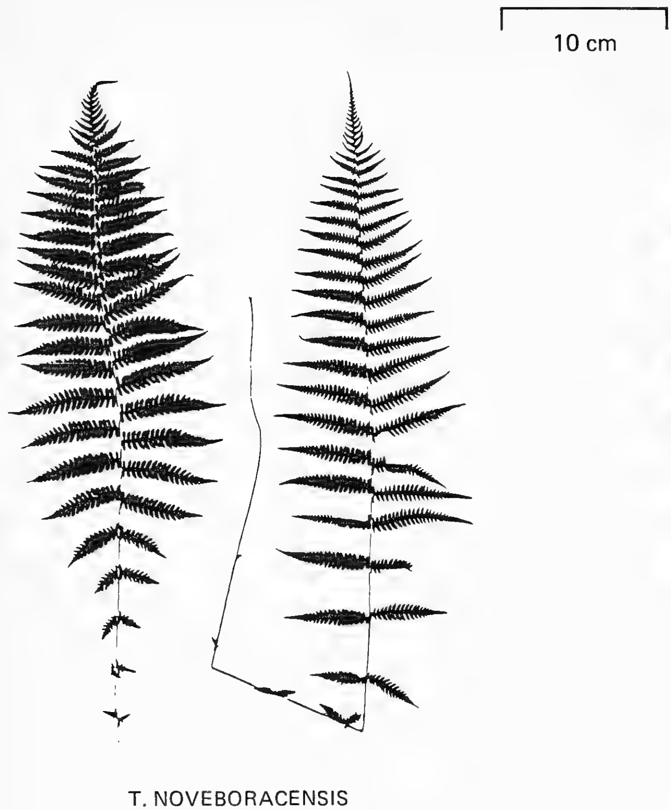
A coastal plain aquatic and shoreline flora is disjunct in Ontario in the eastern Georgian Bay region (Catling et al. 1977; Keddy and Reznicek 1982). Since certain bog-loving coastal plain elements have recently been discovered in this region (Reznicek and Whiting 1976; Whiting and Bobbette 1974), it seems possible that the Massachusetts Fern may also occur there. However, attempts to find it there have so far been fruitless (A. A. Reznicek, personal communication).

Identification

Smaller fronds of Cinnamon Fern are sometimes confused with Massachusetts Fern. The former differs in having tufts of brown hair below at the bases of the pinnae, a cobwebby rachis, forked veins in the pinnules and tufted fronds.

According to Davenport (1894) who provided the specific epithet, "*simulata*" refers to the resemblance of Massachusetts Fern to both the Marsh Fern and the New York Fern (*Thelypteris noveboracensis* (L.) Nieuwl.) (Wherry 1961). These three species have the fronds arising singly from an elongate rhizome. In New York Fern, the fronds are strongly narrowed toward the base (Figure 4), the lowest pinnae being rudimentary. Both Massachusetts Fern and Marsh Fern have narrowly lanceolate fronds only slightly narrowed to the base (Figure 4). The difficulty in identifying Massachusetts Fern is in separating it from Marsh Fern. These taxa share a number of distinctive characters, especially their narrowly-lanceolate frond shape and their black, scaly, long-creeping rhizomes.

Most keys distinguish Massachusetts Fern by the non-dividing veins in both the sterile and fertile fronds. In contrast, the sterile fronds of Marsh Fern always have up to 70% divided veins (Figure 5). The key to Polypodiaceae in Gleason and Cronquist (1963) and Gleason (1952) does not work for this reason. As correctly noted by Fernald (1929), Marsh Fern has most veins in fertile fronds undivided but the basal veins in the pinnules are often divided. This separation based on presence or absence of dividing



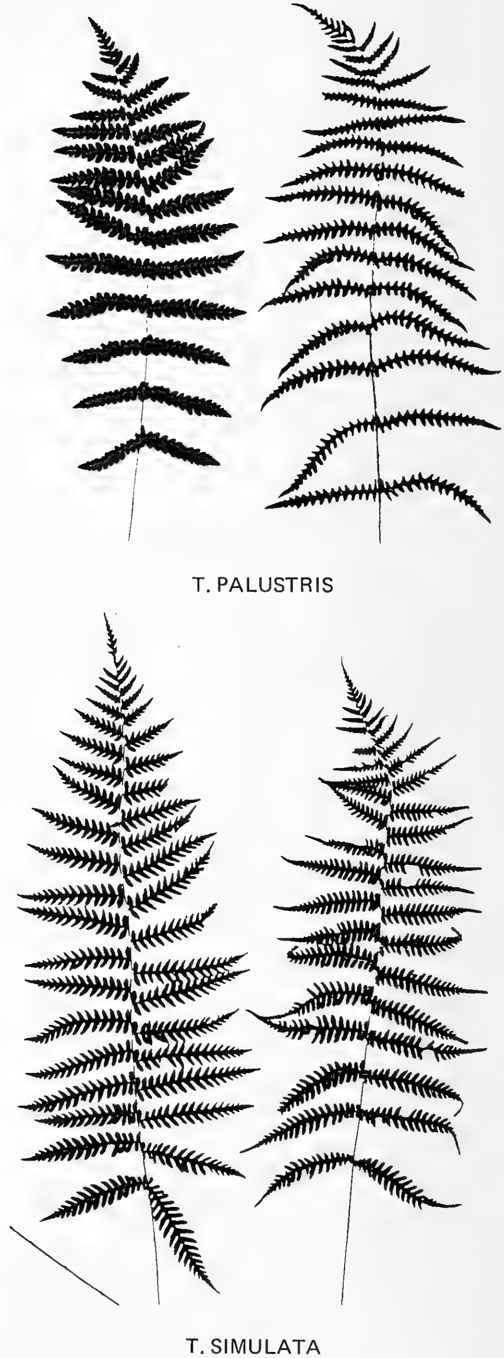


FIGURE 4. Frond silhouettes of New York Fern (from Prescott, *Catling s.n.* September 1983, DAO), Marsh Fern and Massachusetts Fern (both from Newington Bog, *Catling s.n.*, September 1983, DAO).

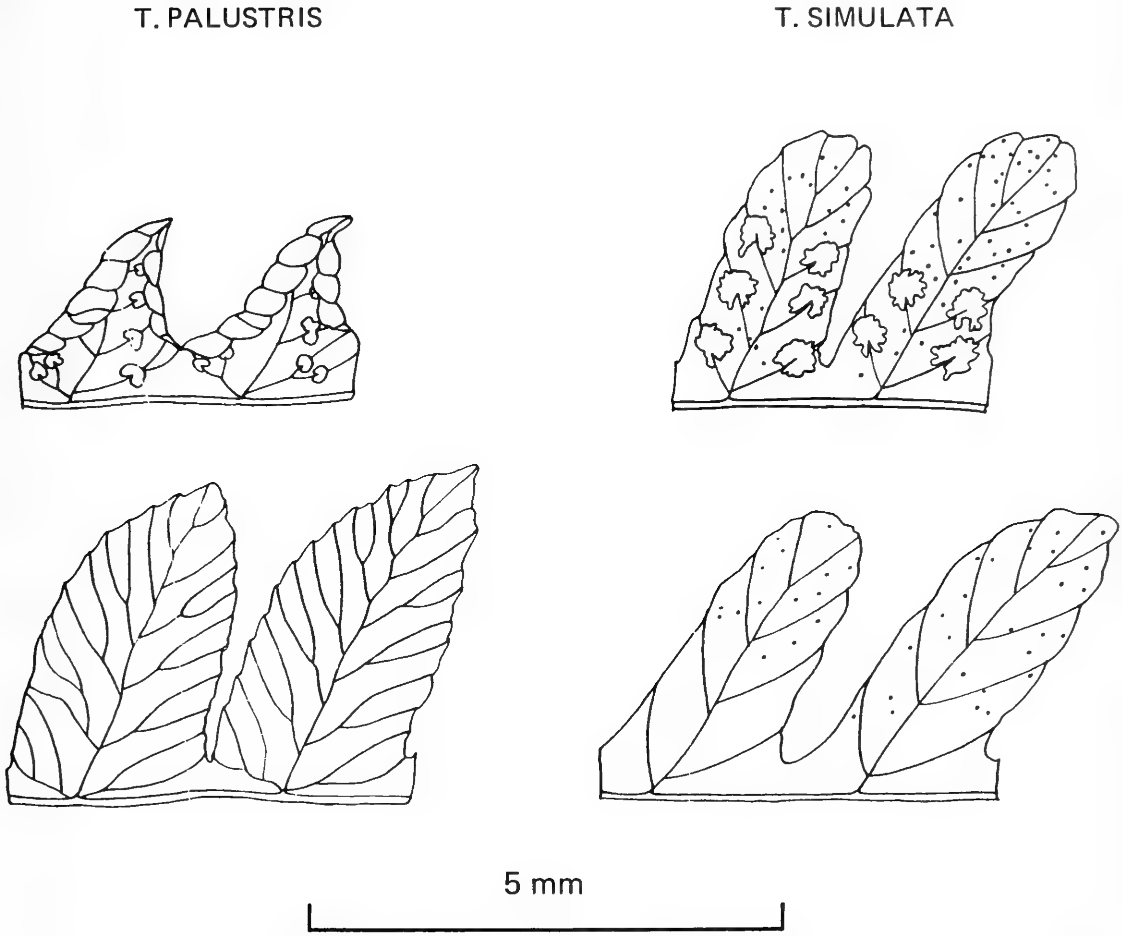


FIGURE 5. Camera lucida drawings of sterile (below) and fertile (above) pinnules of Marsh Fern and Massachusetts Fern both from Newington Bog, Stormont Co., Ontario.

veins works relatively well, but there is no need to rely upon it totally since a few other characters are at least equally useful.

The basal pinnae of Marsh Fern tend to be broad based whereas those of Massachusetts Fern tend to be somewhat narrowed to the base (Figure 4). This is particularly evident in sterile fronds and seems to be a very useful character (Wherry 1961).

In addition the pinnae of Massachusetts Fern tend to be more long-acuminate (Figure 4). Although qualitative, this also has proven to be a reliable character.

Another good frond character of Massachusetts Fern is the more or less ascending and retrorse basal pinnae. The fronds frequently arch strongly, sometimes becoming horizontal. While most of the pinnae are flat (*i.e.* parallel to the surface of the ground), the two basal pinnae are tipped upward, often with an angle of less than 90° between them. As well as being ascending, the basal pinnae are retrorse, *i.e.* directed away from the other pinnae (as in Long Beech Fern (*Phegopteris connectilis*)) and downward when considering the frond axis to be vertical. In pressing a frond to make an herbarium specimen, or when the arching frond is flattened, the retrorse character of the basal pinnae becomes more evident. Thus orientation of the basal pinnae is a useful character, especially in the field, and has been used in some texts (e.g. Cobb 1956). No doubt this is what Davenport (1894) referred to as "one of those indefinable graces of appearance that sometimes gives character and tone to a plant just as a certain air or carriage oftentimes distinguishes one person from another."

In some keys basal pinnae ½ to fully as long as the middle pinnae is used to separate Marsh Fern (*e.g.*

Fernald 1950; Scoggan 1978), but Massachusetts Fern also frequently has basal pinnae in this range. Although it is not a reliable character, the average ratio of the length of the basal pinnae to middle pinnae probably is a higher value in Marsh Fern.

Gleason (1952) indicated that the costae (*i.e.* the central veins of the pinnae and pinnules) are glabrate in Massachusetts Fern and pilosulous in Marsh Fern. This is not a useful character since the veins of Marsh Fern are sometimes glabrate.

The pinnules of fertile fronds of Marsh Fern generally have the margins inrolled on the underside (Figure 5) leading to the very conspicuous frond dimorphism (Figure 4), but in Massachusetts Fern the pinnules are not inrolled or only partly inrolled. This is a helpful qualitative character in the extreme cases but it does not help with some intermediate specimens.

Several keys indicate that Massachusetts Fern has a minutely glandular-ciliate indusium while Marsh Fern has the indusium glabrous or long-ciliate (*e.g.* Fernald 1950; Scoggan 1978; Gleason 1952). This is not a reliable character since plants that are referable to Marsh Fern on all other characteristics sometimes have a very distinctly glandular indusium (*e.g.* Wales, CAN 276966) comparable to that characteristic of Massachusetts Fern. Some of the indusial glands on Massachusetts Fern may be larger than those usually found on a glandular indusium of Marsh Fern (comparable to those on the lower surface), but still the indusial glands are totally misleading on a simple presence or absence basis.

It is noted by Seymour (1969) that J. P. Poole indicated that Massachusetts Fern has lustrous resinous glands on the undersurface of the frond (under powerful magnification), that the lowest pinnae are not the longest, and that the pinnae are not exactly opposite. The two latter characters are inconsequential in separating Massachusetts Fern from Marsh Fern since there are frequent exceptions. Unlike the indusial glands, the lustrous resinous glands on the lower leaf surface (Figure 5) are a very distinctive feature of Massachusetts Fern.

Cobb (1956) suggests using scaliness of the stalk to separate Marsh Fern from Massachusetts Fern. While Massachusetts Fern is definitely more scaly, mature or older stalks can readily be matched by younger stalks of Marsh Fern. Therefore, this character is not recommended.

The following key is based on the preceding discussion:

1. Fronds strongly narrowed toward the base with the lowest pinnae being rudimentary (Figure 4) .... *T. noveboracensis* (New York Fern)
1. Fronds only slightly or not at all narrowed toward the base, the lowest pinnae well developed (Figure 4) 2
2. Pinnae narrowed to the base (Figure 4) and long acuminate at the tip; fronds with lustrous resinous glands beneath (using high magnification) (Figure 5); lateral veins of the pinnules of both sterile and fertile fronds not forking (Figure 5) .... *T. simulata* (Massachusetts Fern)
2. Pinnae broad-based and broadly pointed at the tip (Figure 4); fronds without lustrous resinous glands beneath (Figure 5); lateral veins of the pinnules of sterile fronds mostly forking, of the fertile fronds simple or forked (Figure 5) .... *T. palustris* (Marsh Fern)

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ONTARIO, Prescott County, Alfred Bog, near Horse Creek at UTM 157391, Caledonia Tp., *ca.* 4 km south of Caledonia Springs, 5 June 1983, *P. M. Catling s.n.* (DAO), 16 June 1983, *P. M. Catling* & *V. R. Brownell s.n.* (DAO, MICH, OAC, TRTE).

Stormont County, Newington Bog, *ca.* 4 km SW of Avonmore, UTM 046983, on the west side of the road, Roxborough Tp., 19 June 1983, *P. M. Catling s.n.* (DAO, MICH, OAC, TRTE).

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Received 3 January 1984
Accepted 28 August 1984

Species Composition and Biomass of the Macrophyte Vegetation of one Acidified and two Acid-sensitive Lakes in Ontario

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Wile, I., G. E. Miller, G. G. Hitchin, and N. D. Yan. 1985. Species composition and biomass of the macrophyte vegetation of one acidified and two acid-sensitive lakes in Ontario. Canadian Field-Naturalist 99(3): 308–312.

The composition and biomass of the aquatic macrophyte community of Clearwater Lake, an acidified (pH 4.3), metal-contaminated lake near Sudbury, Ontario were compared with those of two lakes (Harp and Red Chalk) with floras typical of non-acidic oligotrophic lakes in south-central Ontario. Clearwater Lake had far fewer species of macrophytes than the other two lakes, probably because of its high trace metal levels. Average macrophyte biomass, however, was not only much higher in Clearwater Lake than in Harp and Red Chalk Lakes, but exceeded all previous records of biomass for oligotrophic, soft water lakes.

Key Words: Macrophyte biomass, acid lakes, metals, Sudbury.

Field surveys of acidified Precambrian Shield lakes in Scandinavia and in northeastern North America have demonstrated that phytoplankton, zooplankton, benthic macroinvertebrate and fish communities are negatively affected by depression of lake water pH to levels $\leqslant 5.5$ (reviewed by Harvey et al. 1981; Haines 1981; and Dillon et al. 1984, among others). Impacts of acidification on aquatic macrophytes have received comparatively less attention. In Swedish acidified lakes the bryophyte *Sphagnum* often replaces various isoetid species as a community dominant (Grahn 1977; Hultberg and Grahn 1976; Hultberg 1977). In Lake Orvattnet, for example, bottom cover by *Sphagnum* in the 0–2 m depth zone increased from 8% in 1967 to 63% in 1974 while pH levels declined by 0.8 units. Dense monospecific beds of *Sphagnum* have also been observed in acidic (pH 4.9) Colden Lake in the Adirondack Mountains in New York State (Hendrey and Vertucci 1980), but such accumulations do not appear to be characteristic of acidic lakes in North America (Singer et al. 1983; Wile and Miller 1983).

Gorham and Gordon (1963) were the first to indicate that vascular macrophytes might be affected by acidification of Canadian lakes. In a survey of 29 lakes near Sudbury, Ontario, they found that macrophyte species richness increased with distance from Sudbury. They suggested that elevated metal levels rather than the high acidity of lakes near Sudbury were responsible for the poor floras of lakes near the city. In a survey including several acidic lakes at greater distances from Sudbury, Wile and Miller (1983) found floras to be impoverished only in those acidic lakes which also had elevated metal levels. This was consistent with Gorham and Gordon's hypothesis.

While acidification of lakes affects the vertical zonation of macrophyte species (Singer et al. 1983), it is not yet known if changes in total or relative abundance of aquatic macrophytes are to be anticipated in lakes in North America that have acidified. In this report the submersed and floating-leafed flora of an acidified, metal-contaminated lake near Sudbury (Clearwater Lake) is compared with those of Harp and Red Chalk Lakes, two acid-sensitive soft water lakes in the Muskoka District of Ontario. Differences between the lakes are examined to see if acidification and/or contamination with trace metals might influence total macrophyte biomass or the relative abundance of macrophyte species.

Description of the Study Lakes

Extensive hydrological, chemical and planktonic data for the study lakes have been reported elsewhere (e.g. Dillon et al. 1978, 1979). Lake location and selected morphometric parameters are indicated in Table 1. Clearwater Lake is located 13 km south of the copper-nickel smelting complex at Copper Cliff, just west of Sudbury, Ontario. The lake has been acidic (pH < 4.5) for at least two decades (Yan 1979). Levels of several trace metals are greatly elevated (Table 1) as a result of unusually high rates of atmospheric loading (e.g. Cu and Ni: Jeffries and Snyder 1981), or high rates of mobilization of metals (e.g. Al and Mn) from watershed materials (Dillon et al. 1980).

Typical of most Precambrian Shield lakes, the three lakes had low levels of total phosphorus (Table 1). Conductivity and Ca levels in Clearwater Lake were somewhat greater than in the other two lakes because high levels of acid deposition have increased weathering rates of materials in the watershed of the lake (Dillon et al. 1980). While precipitation in the

TABLE 1. Location and selected morphometric and chemical data for the study lakes (from Dillon unpublished data, and Yan and Miller 1984).

Parameter		Harp	Red Chalk	Clearwater
Latitude	(°N)	45°23′	45°11′	45°22′
Longitude	(°W)	79°08′	78°56′	81°03′
Area	(ha)	66.9	56.9	76.5
Mean depth	(m)	12.4	14.2	8.1
Maximum depth	(m)	40	38	22
Secchi transparency	(m)	3.4	6.1	9.7
pH		6.7	6.6	4.4
Conductivity	(u S cm^{-1})	34	29	86
Alkalinity	(ueq L^{-1})	92	95	<0
Total phosphorus	(ug L^{-1})	5	5	4
Calcium	(mg L^{-1})	3	3	6
Sulphate	(mg L^{-1})	9	8	24
Copper	(ug L^{-1})	<2	<2	76
Nickel	(ug L^{-1})	<2	<2	255
Zinc	(ug L^{-1})	7	6	37
Manganese	(ug L^{-1})	12	12	303
Iron	(ug L^{-1})	38	51	57
Aluminum	(ug L^{-1})	56	24	332

watersheds of Harp and Red Chalk Lakes is very acidic (Dillon et al. 1978) and temporary reductions in lake pH have been observed (Jeffries et al. 1979; Scheider et al. 1979), the average pH of the lakes remains circumneutral (Table 1).

Human usage of the three lakes is entirely recreational. There are 36 dwellings on the shores of Clearwater Lake, 83 on Harp Lake and three on Red Chalk Lake. Most are used in the summer only. The watersheds of the lakes are virtually continuously forested.

The greatest biomass of isoetid vegetation (the dominant plants in soft water lakes) is found in waters < 4 m deep (Moeller 1975; Nygaard 1958; Sand-Jensen and Sondergaard 1979). Harp and Red Chalk Lakes have steeply sloping bottoms, consequently only 25% and 21% respectively, of their bottom area is overlain by waters < 4 m deep. Clearwater Lake has several extensive shallow areas with gently sloping bottoms and 33% of its bottom area falls within the 0–4 m depth zone. Hence, Clearwater Lake has a greater area potentially suitable for good growth of isoetid vegetation.

Methods

In May 1978, divers using snorkelling gear or S.C.U.B.A. swam the entire perimeter of Harp, Red Chalk and Clearwater Lakes, and mapped macrophytic vegetation from the shore to the maximum depth of colonization. Samples of all species of submersed and floating-leafed macrophytes (tracheophytes, bryophytes and charaphytes) were collected and subsequently identified using Fasset (1957). The percentage bottom cover of each species was visually estimated.

Biomass was determined on a monthly basis from May through August, 1978 using a destructive harvesting technique. Quadrats (0.25 m^2) were positioned using a stratified random design. The total number of quadrats was distributed equally among areas determined by divers to have similar floras and relative and total cover estimates. The quadrats were positioned randomly within each area. All enclosed plant material including roots was removed from each quadrat. Plants were washed free of sediment and dried at 105°C to a constant weight. Through the season a total of 44 quadrats were collected from 11 sites in Harp Lake and 56 quadrats from 14 sites in each of Red Chalk and Clearwater Lakes.

As visual estimates of bottom cover are subjective, the data were used conservatively to aid in the calculation of plant biomass. A relative frequency histogram of cover estimates in the lakes was constructed. The distribution was bimodal. Therefore, a weighted total plant biomass was generated on each date by summing the products of average biomass in low and high cover zones (less than and greater than 50% cover) with the proportion of the vegetated area of the lake exhibiting low and high cover, respectively.

Results and Discussion

Macrophyte Distribution, Species Composition and Dominance

Macrophytes colonized less than 10% of the total surface areas of Harp and Red Chalk Lakes. Areas of dense growth were generally found adjacent to inflow-

TABLE 2. Species composition and abundance[a] of macrophytes in the study lakes. The abundance ratings, based on the frequency of occurrence at the sampling sites are A (85–100% occurrence), C (50–84% occurrence), 0 (< 50% occurrence) and R (1 occurrence). Average biomass estimates in vegetated zone for the study lakes (± 95% confidence limits) are indicated.

	Harp	Red Chalk	Clearwater
Vascular Plants			
Eleocharis acicularis	O	R	O
Eriocaulon septangulare	A	A	A
Isoetes sp.	C	O	—
Juncus pelocarpus	O	O	O
Lobelia dortmanna	O	C	—
Lycopus sp.	—	—	R
Myriophyllum tenellum	—	O	O
Sparganium angustifolium	R	—	—
Utricularia minor	R	—	—
Utricularia purpurea	—	R	—
Utricularia vulgaris	O	R	—
Utricularia resupinata	—	R	—
Potamogeton natans	R	—	—
Potamogeton epihydrus	R	—	—
Nymphaea odorata	O	O	—
Brasenia schreberi	O	O	—
Pontederia cordata	O	O	—
Stoneworts			
Nitella flexilis	O	—	—
Mosses and Liverworts			
Cladopodiella fluitans	—	—	O
Drepanocladus exannulatus	—	—	C
Fontinalis antipyretica	O	O	—
Sphagnum subsecundum Nees *ex* sturm.	R	—	—
Mnium pseudopunctatum	R	—	—
Eurhynchium riparioides	R	—	—
Total Biomass (g m^{-2} dry wt.)	73.6 ± 16.0	59.2 ± 7.2	326 ± 83.2

[a]Abundance estimates were confirmed in a subsequent survey in 1982.

ing streams. The vegetation was dominated by pipewort, *Eriocaulon septangulare*. In Clearwater Lake, in contrast, macrophytes colonized some 15% of the lake and the nearshore areas were characterized by very dense mats of pipewort.

In all three lakes maximum depth of plant occurrence approximated the Secchi transparency (Table 1). Harp and Red Chalk Lakes supported vegetation to depths of 3 and 4 m, respectively. In Clearwater Lake, scattered patches of the bryophyte *Drepanocladus exannulatus* were observed at depths of 8 m.

Floristically, Harp and Red Chalk Lakes were similar (Table 2). They supported 18 and 13 plant species, respectively, and of these, 10 were common to both lakes. Both the species richness and species composition were comparable to other soft water lakes of Ontario (Miller 1977). In comparison there were only eight plant species in Clearwater Lake.

Without pre-acidification floristic descriptions of Clearwater Lake, it cannot be concluded that species richness decreased in the lake when it acidified and became contaminated with metals. Nevertheless, extensive surveys of lakes in the area indicate that such a reduction has almost certainly occurred. It is probably attributable to high metal levels rather than to low lake water pH (Gorham and Gordon 1963; Wile and Miller 1983).

Although there are floristic differences between Clearwater Lake and the two Muskoka lakes some similarities also existed. The floras of the three lakes were predominantly isoetid in character and each was dominated by *E. septangulare*. There was a general paucity of bryophytes, with only *D. exannulatus* abundant in Clearwater Lake and *Fontinalis antipyretica* in Harp and Red Chalk Lakes. *Sphagnum subsecundum* was found at only one site in Harp Lake. Major perturbations of the flora, such as extensive *Sphagnum* invasions and losses of isoetid vegetation were not apparent in any of the lakes although they have been observed elsewhere (Grahn 1977).

Macrophyte Biomass

There was no trend in macrophyte biomass in any of the lakes over the ice-free season. This is consistent

with other investigations (Sand-Jensen and Sondergaard 1979; Moeller 1975). Average macrophyte biomass in Red Chalk and Harp Lakes was similar at 59.2 and 73.6 g m^{-2} of vegetated zone, respectively. A much higher average value of 326 g m^{-2} was calculated for Clearwater Lake (Table 2).

A very wide range of average macrophyte biomass has been recorded for oligotrophic lakes. Lowest values of 0.085 to 0.52 g m^{-2} (dry weight for the vegetated zone) were reported by Wilson (1935 in Hutchinson 1975) for three lakes in Wisconsin. Levels in Mirror Lake in New Hampshire were much higher, at 7.1 g m^{-2} (Moeller 1975). The highest recorded value for an oligotrophic lake is for Lake Kalgaard in Denmark. Sand-Jensen and Sondergaard (1979) reported an average biomass of 188 g ash free dry weight m^{-2} of vegetated zone for the lake, or 221 g m^{-2} assuming a plant ash content of 15% of dry weight (Moeller 1975).

The macrophyte biomasses of Harp and Red Chalk Lakes were within this recorded range for oligotrophic lakes. The biomass of Clearwater Lake was not only much higher than that of the other two study lakes, but it exceeds all previously recorded biomass estimates for oligotrophic lakes. The biomass of Clearwater Lake is actually comparable to the midsummer peak in biomass of the vittate macrophyte communities characteristic of hard water, eutrophic environments (200–400 g m^{-2}: Rickett 1922 and 1924, Carpenter 1979). The exceptionally high biomass in Clearwater Lake is surprising in view of the lake's elevated metal levels and very acidic waters. Obviously, *E. septangulare* and *D. exannulatus* are highly tolerant of such conditions.

The spatial (vertical and horizontal) distribution of biomass and of productivity of primary producers (benthic and planktonic algae and macrophytes) is probably influenced by the acidification of lakes. The great clarity of acidic lakes allows for the development of subthermocline production maxima of phytoplankton (Schindler 1980; Yan and Miller 1984) and may explain the successful invasion of profundal sediments by vascular macrophytes (Singer et al. 1983). Shifts in relative abundance of primary producers from the pelagic to the littoral are indicated by frequent reports of dense accumulations of benthic algae in the littoral zone of acidified lakes both with and without elevated levels of trace metals (Stokes 1981). This report presents the first indication that the biomass of aquatic macrophytes may also be much greater in the littoral zone of an acidified, metal-contaminated lake than in circumneutral lakes of similar nutrient status. Whether this observation is applicable to acid or acid and metal contaminated lakes in general must await the results of additional surveys.

Acknowledgments

We thank P. J. Dillon for use of unpublished chemical data from the study lakes and three anonymous reviewers for their helpful criticisms of the manuscript.

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Received 2 December 1983
Accepted 12 September 1984

Winter Use of Arboreal Lichens, Ascomycetes, by White-tailed Deer, *Odocoileus virginianus*, in Maine

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Hodgman, Thomas P., and R. Terry Bowyer. 1985. Winter use of arboreal lichens, Ascomycetes, by White-tailed Deer, *Odocoileus virginianus*, in Maine. Canadian Field-Naturalist 99(3): 313–316.

Winter use of arboreal lichens (*Usnea*, and *Evernia*) by White-tailed Deer (*Odocoileus virginianus*) was studied in Unity, Maine from 24 March to 13 May 1984. Lichen biomass was significantly greater immediately above than within the reach of deer; a marked "browse line" produced by deer use of lichens was evident throughout the wintering area. The greatest lichen biomass occurred on White Pine (*Pinus strobus*), White Spruce (*Picea glauca*), and Red Maple (*Acer rubrum*). Deer consumed 63% of *Usnea* and 56% of *Evernia* provided at feeding stations. Use of arboreal lichens by deer dropped precipitously in early May as succulent forbs and grasses became available in nearby fields. Crude protein and energy available from arboreal lichens compare favorably with other winter forages and offer one explanation for their heavy use by wintering deer.

Key Words: White-tailed Deer, *Odocoileus virginianus*, lichen, *Usnea*, *Evernia*, winter, food habits, Maine.

Winter use of arboreal lichens (Ascomycetes) has been reported for Caribou (*Rangifer tarandus*) (Bergerud 1972; Cringan 1957; Edwards and Ritcey 1960; Edwards et al. 1960; Layser 1974; Van Daele and Johnson 1983), Mule Deer (*Odocoileus hemionus*) (Brooks et al. 1972; Linsdale and Tomich 1953), and White-tailed Deer (*Odocoileus virginianus*) (Hosley and Ziebarth 1935; Wetzel et al. 1975). Moreover, the dynamics of epiphytic lichen communities are well-documented (Lang et al. 1980; Taylor 1922; Wein and Speer 1975). However, quantitative information on the importance of lichens in the winter ecology of White-tailed Deer is scant.

We observed that epidendric lichens in a White-tailed Deer wintering area were luxuriant directly above the reach of deer, but uncommon on the lower branches and boles of trees. This obvious "browse line" suggested deer fed extensively on these epiphytes, and that arboreal lichens may be important in winter nutrition. This study identified epiphytic lichens consumed by White-tailed Deer, quantified lichen biomass on common trees, and evaluated the availability and use of lichens in a deer wintering area.

Study Area

Research was conducted at an elevation of 76 m in a known deer wintering area 3 km south of Unity, Waldo County, Maine, USA (44° 36′N, 69° 23′W). The area encompassed three km^2 of boreal forest composed largely of Balsam Fir (*Abies balsamea*), White Spruce (*Picea glauca*), White Pine (*Pinus strobus*), Eastern Hemlock (*Tsuga canadensis*), and Northern White Cedar (*Thuja occidentalis*) intermixed with northern hardwoods. Small brooks and swamps abound; hay fields adjoin the eastern edge of the area. Annual snowfall averages 250 cm; winter minima may fall to –35° C. Climatic conditions during the winter of 1984 were moderate.

Methods

Dry weight biomass was determined for fruticose lichens from March to April 1984 on trees with diameters at breast height (DBH) $\geqslant$ 10 cm. Samples were collected by walking along nine randomly selected transects each 100 m in length and 1 m in width. Sampling procedures for lichens followed Van Daele and Johnson (1983), except that only two plots per tree were sampled. The first plot was 1.15–1.35 m above the packed snow, well within the reach of deer but above that of Snowshoe Hare (*Lepus americanus*). The second plot was 2.40 –2.60 m above the packed snow and was directly above the reach of foraging deer. The height of the first arboreal lichen above the snow without signs of deer use ($\geqslant$ 4 cm in length) also was recorded as an index to "browse line" height on each tree. Bowyer and Bleich (1980) found that browse line height for some deer forages was a reliable measure of the intensity of deer use of an area. Additionally, tree species, DBH, and canopy closure were recorded for each tree sampled; the last variable was measured with a forest densiometer (Lemmon 1957). Lichen taxonomy and identification followed Hale (1974). All lichens removed from sampling plots were stored in paper sacks at room temperature until laboratory analysis. Lichens were oven dried at 50° C for 48 h and weighed individually to the nearest 0.0001 g.

The use of lichens by deer was evaluated further by providing feeding stations along well-traveled deer trails. These stations consisted of a small branch to

TABLE 1. Dry weight biomass (g) of *Usnea laricina* in plots on tree boles above (2.40–2.60 m) and within (1.15–1.35 m) the reach of White-tailed Deer in central Maine, March-May 1984. *P* = significance level from Mann-Whitney *U*-test comparing plots above and within deer reach.

		2.40–2.60 m				1.15–1.35 m		
Species	N	$\overline{X}$	SD	Range	*P*	$\overline{X}$	SD	Range
Abies balsamea	15	0.002	0.005	0-0.017	0.457	0.002	0.004	0-0.014
Acer rubrum	27	0.096	0.181	0-0.864	0.007	0.005	0.013	0-0.057
Betula papyrifera	3	0		0		0		0
Betula populifolia	5	0.019	0.042	0-0.095	0.576	0.002	0.004	0-0.009
Larix laricina	2	0.059	0.055	0.020-0.098	0.118	0		0
Picea glauca	28	0.104	0.339	0-1.791	0.071	0.016	0.038	0-0.174
Pinus strobus	21	0.121	0.182	0-0.627	0.006	0.009	0.020	0-0.084

which 4–6 lichens were attached with lightweight monofilament line. Three of these branches were placed vertically into the snow at each feeding station and were arranged so lichens were at least 0.75 m above the snow. The snow around each branch was prepared so that the tracks of animals using a feeding station would be evident. Stations were checked at no greater than two-week intervals. Branches toppled in storms were not considered in the analysis of lichen utilization. Percent removal of lichens was determined from the difference in wet weight biomass of these epiphytes before and after use by deer.

Energetic and crude protein values of forage lichens were determined using standard bomb calorimetry and micro-Kjeldhal procedures (Horwitz 1975). Statistical analyses included a two-sample *Z*-test for proportions (Remington and Schork 1970), a Mann-Whitney *U*-test, and Spearman rank correlation (Siegel 1956).

Results

Only two species of arboreal lichens (*Usnea laricina* and *Evernia mesomorpha*) showed evidence of deer use. Twelve species of trees totaling 126 individuals were sampled for the presence of these dendric lichens; epiphytes were present in 54.8% of the samples. Neither *Usnea* nor *Evernia* occurred on six tree species (*Fraxinus nigra, Ostrya virginiana, Populus tremuloides, Thuja occidentalis, Tsuga canadensis, Ulmus americana*); trees without lichens on their boles or lower branches tended to have corky or shredding bark.

The mean "browse line" height for lichens was 1.7 m (SD = 0.62 m). A Mann-Whitney *U*-test showed that the combined dry weight biomass of *Usnea* and *Evernia* for trees possessing these lichens was significantly ($P < 0.001$) greater immediately above the reach of deer ($\overline{X}$ = 0.104 g, SD = 0.211 g) than within reach ($\overline{X}$ = 0.015 g, SD = 0.029 g). Significantly more *Usnea* ($\overline{X}$ = 0.082 g, SD = 0.220 g) than *Evernia* ($\overline{X}$ = 0.022 g, SD = 0.74 g) occurred in plots both above ($P < 0.001$) and within (*Usnea* $\overline{X}$ = 0.008 g, SD = 0.024 g; *Evernia* $\overline{X}$ = 0.007 g, SD= 0.030 g; $P < 0.05$) deer reach. Overall differences in the biomass of lichens above and within the reach of deer differed significantly for *Usnea* ($P < 0.001$) but not *Evernia* ($P > 0.13$). For individual tree species significant differences in *Usnea* biomass above and within deer reach occurred for *Acer rubrum* and *Pinus strobus* (Table 1); no significant differences were found for *Evernia* (Table 2). Too few dead trees were encountered during sampling to test for differences in lichen biomass between living and dead specimens.

Lichen biomass directly above deer reach was inversely correlated with canopy closure (r_s = –0.279, $P < 0.001$, 124 d.f.); the mean overstory closure for this area was 92% (SD = 22.9%). Mean DBH of trees sampled was 18.5 cm (SD = 8.6 cm); lichen biomass was not related significantly to DBH (r_s = 0.140, $P > 0.11$, 124 d.f.).

Wet weight biomass of lichens available to deer on each branch at feeding stations averaged 3.89 g (SD = 1.27 g) for *Usnea* and 1.32 g (SD = 1.10 g) for *Evernia*. Overall, 63.1% of *Usnea* and 56.1% of *Evernia* were removed between 24 March and 13 May 1984; this difference was not significant (Z = 0.47, $P > 0.63$). Only tracks of White-tailed Deer were observed around feeding stations. Use of lichens at feeding stations by deer was high from late March to April, but dropped appreciably during May (Figure 1). This decline in the use of lichens by deer coincided with the proliferation of succulent forbs and grasses in nearby fields.

A Mann-Whitney *U*-test showed crude protein content for three samples each of *Usnea* ($\overline{X}$ = 7.3%, SD = 0.26) and *Evernia* ($\overline{X}$ = 5.1%, SD = 0.24%) differed significantly ($P < 0.05$). The mean energetic content for *Usnea* (4.012 Kcal/g, SD = 0.101 Kcal/g) was not significantly different ($P > 0.50$) from that of *Evernia* ($\overline{X}$ = 3.966 Kcal/g, SD = 0.137 Kcal/g).

TABLE 2. Dry weight biomass (g) of *Evernia mesomorpha* in plots on tree boles above (2.40–2.60 m) and within (1.15–1.35 m) the reach of White-tailed Deer in central Maine, March-May 1984. *P* = significance level from Mann-Whitney *U*-test comparing plots above and within deer reach.

		2.40–2.60 m				1.15–1.35 m		
Species	N	$\bar{X}$	SD	Range	*P*	$\bar{X}$	SD	Range
Abies balsamea	15	0.009	0.017	0-0.047	0.09	< 0.001	< 0.001	0-< 0.001
Acer rubrum	27	0.036	0.101	0-0.408	0.155	0.005	0.018	0-0.077
Betula papyrifera	3	0		0	0.520	0.001	0.002	0-0.003
Betula populifolia	5	0.062	0.139	0-0.310	0.687	0.004	0.007	0-0.017
Larix laricina	2	0		0		0		0
Picea glauca	28	0.023	0.077	0-0.340	0.499	0.004	0.013	0-0.050
Pinus strobus	21	0.009	0.028	0-0.120	0.551	0.019	0.059	0-0.269

Discussion

A marked "browse line" on arboreal lichens, significantly more lichens immediately above than within the reach of deer, and substantial use of lichens at feeding stations all suggest these epiphytes are an important winter forage of White-tailed deer in Maine. Significantly more *Usnea* than *Evernia* was available to deer. Further, significant differences occurred in the amount of *Usnea* above and within deer reach; this was not the case for *Evernia*. The relative scarcity of *Evernia* on trees may have been one reason for its infrequent use by deer; no significant difference in percent removal between *Usnea* and *Evernia* occurred at feeding stations where both were readily available.

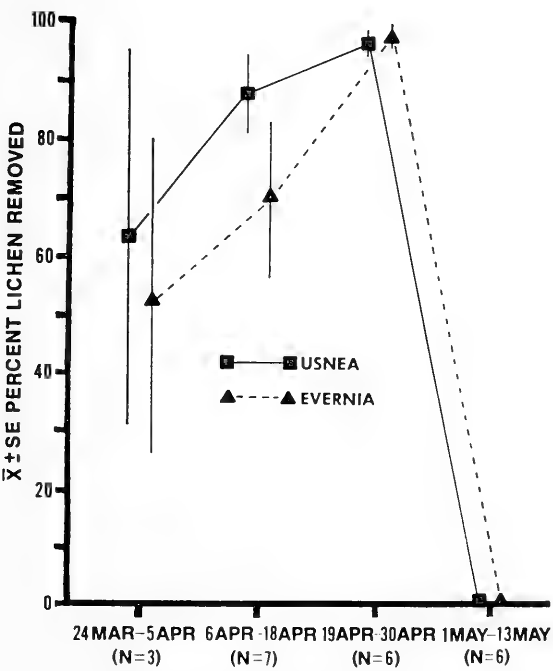

FIGURE 1. Percent removal of arboreal lichens from feeding stations by White-tailed Deer from late March through mid-May 1984, Unity, Maine.

The percent occurrence of dendric lichens on tree boles tends to increase with the age of the stand (Lang et al. 1980); old-growth forests typically are used for winter shelter by White-tailed Deer in northern latitudes (Crawford 1982; Euler and Thurston 1980; Huot 1974; Verm 1965; Wetzel et al. 1982). The availability of lichens in wintering areas may play an important role in the nutrition of deer. Hale (1974) noted sunlight was important in the growth of lichens. The inverse relation between lichen biomass and canopy cover in this study supports this observation. Future management of deer wintering areas should consider practices that favor lichens.

Winter use of arboreal lichens by White-tailed Deer probably relates to the nutritive value of these epiphytes. Scotter (1965) reported substantial nitrogen free extracts (> 78%) for arboreal lichens, suggesting a high digestibility of these species. Further, he noted a mean crude protein content of 3.9% for *Usnea hirta* and 4.6% for *Evernia mesomorpha*; our values for these genera were somewhat higher. Lang et al. (1980) noted 7.5% crude protein in both *Usnea* and *Evernia*. The crude protein and energy content for Northern White Cedar, an important winter forage for deer, were 3.3% and 2.37 Kcal/g, respectively (Ullrey et al. 1968). Further, Palmer and Cowan (1980) noted the digestibility of White Cedar was about 45% on a dry weight basis. Thus, the combination of moderate crude protein and energy values coupled with a high digestibility make *Usnea* and *Evernia* suitable winter forage. However, the use of lichens declined rapidly as more succulent forage became available in early May.

Caribou ferment carbohydrates with a rumen microflora specifically adapted for lichens (Dehority 1975a, 1975b). Moreover, a diet high in lichens is thought to facilitate the transfer of urea from the

plasma to the rumen (Wales et al. 1975), and to help increase the total amount of body water which may act as a thermal buffer against changes in temperature (Cameron et al. 1975). Whether similar physiological changes occur in deer feeding on lichens is yet unknown.

Acknowledgments

Funding for this project was provided, in part, by the Penobscot County Conservation Association. We thank G. P. Madden for his help with lichen sampling, and M. A. Rosinski for aiding in the identification of lichens. We gratefully acknowledge R. E. Barry, Jr. for assisting with the bomb calorimetry; J. A. Jenks and R. E. Barry critically reviewed the manuscript.

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Received 13 June 1984
Accepted 12 August 1984

New Fish Distribution Records in Manitoba and the Role of a Man-Made Interconnection Between Two Drainages as an Avenue of Dispersal

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The first record of *Pomoxis annularis* in Manitoba and range extensions within Manitoba for *Umbra limi, Notropis dorsalis, Notropis heterodon, Carpiodes cyprinus, Ictiobus cyprinellus, Moxostoma macrolepidotum, Ictalurus melas, Noturus flavus, Noturus gyrinus, Fundulus diaphanus,* and *Morone chrysops* are presented and discussed. *Notropis heterodon* and *N. dorsalis* probably were overlooked or misidentified previously, while all the other species seem to represent a combination of real extensions of range, increases in abundance where found, and/or recent increases in collecting effort. The opening of the Assiniboine River Floodway has provided an access route for *Umbra limi, Ictiobus cyprinellus, Ictalurus melas, Noturus gyrinus,* and probably *Ictalurus punctatus,* to reach southern Lake Manitoba.

Key words: fish, range extensions, Manitoba, Nelson River Basin, river diversion, zoogeography.

Since the publication of Fedoruk (1971) and Scott and Crossman (1979), significant extensions of range within Manitoba have been noted for ten species of fishes. Two species previously unknown to the province, one reported by Babaluk and Harbicht (1984) have also been discovered. In this paper we present these records in detail and discuss the effects of a man-made drainage basin interconnection on the spread of some of these species. Several of these records will also be referred to in Crossman and McAllister (in press) since we have exchanged specimens and data with them.

Range Extensions

A summary of new Manitoba collection and locality records is presented for each species in Table 1. Table 2 gives meristic and morphological data for specimens of each species from the new localities. The characters for each species are consistent with those recorded by Scott and Crossman (1979) with the exceptions of pharyngeal tooth counts for *Notropis heterodon* and longest gill raker as % TL in *Carpiodes cyprinus* (Table 2).

Umbra limi, CENTRAL MUDMINNOW: Mudminnows were found in Delta Marsh, at the south end of Lake Manitoba during the summer of 1982. Subsequently that summer, one juvenile specimen was collected from Kichie Manitou Lake, an oxbow of the Assiniboine River in Spruce Woods Provincial Park. Both habitats have dense growths of rooted aquatic plants. Delta Marsh becomes oxygen depleted in midsummer, unlike Kichie Manitou Lake, which is spring fed and supports an apparently indigenous complex of fish species different from the adjacent Assiniboine River. Juveniles and larger specimens have been found in both localities, indicating that the species probably is established.

Notropis dorsalis, BIGMOUTH SHINER: Ten Bigmouth Shiners were collected from Oak Creek, near Treesbank, Manitoba in the summer of 1973 (ROM 29840), and an additional two specimens were found in a collection made in summer, 1983 from the Assiniboine River at Brandon. The Oak Creek locality is about 4 km upstream from the junction of the Souris and Assiniboine rivers. The Assiniboine at Brandon is turbid, moderately swift flowing and shallow (mostly $\leqslant$ 1 m depth) with a gravel bottom with an interstitial fill of silt and sand. These conditions are similar to those in the Pembina River, the only locality in Canada where Bigmouth Shiners are common. Pharyngeal tooth count for both specimens was 0,4 – 4,0.

Notropis heterodon, BLACKCHIN SHINER: Blackchin Shiners were collected in summer, 1973, from Oak Creek, in the same locality as described for the Bigmouth Shiner, above (ROM 29841). Subsequently Blackchin Shiners were collected in 1982 from Kichie Manitou and Marsh's lakes, two Assiniboine River oxbow lakes in Spruce Woods Provincial Park. Independently, Babaluk and Harbicht (1984) reported Blackchin Shiners from Dauphin Lake in the same year. In the Assiniboine River oxbow lakes, the species was taken from still, clear, weedy habitats similar to the preferred habitat described by Scott and

TABLE 1. Summary of collection, locality and previously known distribution data for species reported in this paper.

Species	Locality	Collecting Method Date	Nearest Previous Reports	Source
Umbridae *Umbra limi* Central Mudminnow	University of Manitoba Field Station Delta Marsh, South end of Lake Manitoba, (50° 11′N, 98° 23′W)	Minnow Traps, June-August 1982	Red River and eastward, Manitoba	Scott and Crossman 1979; Lee, et al. 1980.
	Kichie Manitou Lake, (oxbow cut off from Assiniboine River) Spruce Woods Provincial Park, (49° 39′N, 99° 18′W)	Seine, 29 August 1982	Not previously reported from Assiniboine River or Lake Manitoba.	
Cyprinidae *Notropis dorsalis* Bigmouth Shiner	Oak Creek, near Treesbank, (49° 37′N, 99° 35′W) ROM 29840	Summer 1973	Pembina River, Twp. 6, RIW (49° 00′–49° 05′N, 98° 12′–98° 21′W), Manitoba	Scott and Crossman 1979.
	Assiniboine River, 200–800 m west of Curran Park, Brandon (49° 51′N, 100° 00′W)	Seine, 5 August 1983	Not previously reported from Assiniboine River	
Notropis heterodon Blackchin Shiner	Oak Creek, near Treesbank (49° 37′N, 99° 35′W) ROM 29841	Summer 1973	(1) Red River drainage of Western Minnesota	(1) Eddy and Underhill 1974; Lee, et al. 1980.
			(2) Lake Dauphin, Manitoba	(2) Babaluk and Harbicht 1984.
	Marsh's and Kichie Manitou lakes, (both oxbows cut off from Assiniboine River), Spruce Woods Provincial Park (49° 39′N, 99° 18′W)	Seine, 26 July, 29 August, 18 September 1982	Not previously reported from Assiniboine River	
Catostomidae *Carpiodes cyprinus* Quillback	Red River at Winnipeg (49° 48′–49° 56′N, 97° 09′W)	Gillnet, Summer 1974	(1) Sheyenne River, North Dakota	(1) Owen, et al. 1981.
			(2) Lakes Winnipeg and Manitoba, Manitoba.	(2) Scott and Crossman, 1979; Lee, et al. 1980.
	Red River at Floodway Control Gate, Winnipeg (49° 48′N, 97° 09′W)	Seine, 18, 25 and 26 September 1980 (and subsequently at same locality)	Not previously reported from Red River	
Ictiobus cyprinellus Bigmouth Buffalo	Delta Marsh south end of Lake Manitoba. (50° 11′N, 98° 23′W)	Hoopnet, 23 May 1983	Red and Assiniboine rivers, Manitoba	Scott and Crossman 1979.
Moxostoma macrolepidotum Shorthead Redhorse	Assiniboine River at Steel Ferry Crossing, Spruce Woods	Angling, 16 July 1981	(1) Red River and Lake Winnipeg, Manitoba	(1,2) Lee, et al. 1980.

TABLE 1. Summary of collection, locality and previously known distribution data (*continued*).

Species	Locality	Collecting Method Date	Nearest Previous Reports	Source
	Provincial Park (49° 39′N, 99° 17′W)		(2) Qu'Appelle River, Saskatchewan	
	Assiniboine River at Spruce Woods Provincial Park campground (49° 39′, 99° 18′W)	Gillnet, 18 September 1982	Not previously reported from Assiniboine River	
Ictaluridae *Ictalurus melas* Black Bullhead	University of Manitoba Field Station Delta Marsh, south end of Lake Manitoba (50° 11′N, 98° 23′W)	Gillnet, seine, minnow and beamish traps, summers of 1974–1983 (Specimens in Table 2 Gillnet, 4 June to 26 July 1982)	Assiniboine River Not previously reported from Lake Manitoba	Scott and Crossman 1979.
Noturus flavus Stonecat	Assiniboine River at Spruce Woods Provincial Park Campground (49° 39′N, 99° 18′W)	Seine, 11 July 1982	Red River at Winnipeg, Manitoba	Stewart and Lindsey 1970.
	Assiniboine River at Brandon (49° 51′N, 100° 00′W)	Seine, 5 August 1983	Not previously reported from Assiniboine River	
Noturus gyrinus Tadpole Madtom	Kichie Manitou Lake, (Oxbow cut off from Assiniboine River) Spruce Woods Provincial Park (49° 39′N, 99° 18′W)	Seine, 29 August 1982	Red River and Lake Winnipeg, Manitoba Souris River, Saskatchewan	Scott and Crossman 1979.
	Assiniboine River at Brandon (49° 51′N, 100° 00′W)	Seine, 5 August 1983	Not previously reported from Assiniboine River or Lake Manitoba	
	University of Manitoba Field Station, Delta Marsh, south end of Lake Manitoba (50° 11′N, 98° 23′W)	Minnow Traps, 6 July-10 August 1982		
Cyprinodontidae *Fundulus diaphanus* Banded Killifish	South Arm, Crowduck Lake, (50° 05′N, 95° 08′W)	Angling, 11 September 1982	(1) Red River at Winnipeg (2) Lake of the Woods, Ontario (3) Red River Tributaries, Minnesota Not previously reported from Winnipeg River System in Manitoba	(1) Stewart-Hay 1954. (2) Foote, personal communication 1982. (3) Eddy and Underhill 1974.

TABLE 1. Summary of collection, locality and previously known distribution data (*concluded*).

Species	Locality	Collecting Method Date	Nearest Previous Reports	Source
Percichthyidae *Morone chrysops* White Bass	Red River at Winnipeg (49°48′–49°56′N, 97°09′W)	Seine, Summer 1974	(1) Lake Winnipeg, Manitoba (2) Sheyenne River, North Dakota Not previously reported from Red River in Manitoba	(1) Scott and Crossman 1979. (2) Owen, et al. 1981.
	Red River at Floodway Control Gate, Winnipeg (49°48′N, 97°09′W)	Seine, 24 September 1981 (and subsequently at same locality)		
Centrarchidae *Pomoxis annularis* White Crappie First record of species in Manitoba	Red River at Floodway Control Gate, Winnipeg (49°48′N, 97°09′W)	Seine, 9 September 1982	(1) Red River Tributaries, in Minnesota (2) Sheyenne River, North Dakota Not previously reported from Manitoba	(1) Eddy and Underhill 1974. (2) Copes 1965.

Crossman (1979). The abundance and large size range suggest that Blackchin Shiners have been established there for some time.

The meristic and morphological data from a sample of 20 Blackchin Shiners collected at Marsh's Lake lies within the ranges given by Scott and Crossman (1979), with the exception that one specimen had a lateral line scale count of 33 (Table 2), and that pharyngeal tooth counts were generally less than those noted by Scott and Crossman (1979). Pharyngeal tooth counts for the 20 specimens follow. Tooth numbers are to the left in each column and numbers of specimens to the right, in parentheses.

Left Side Lesser Row		Left Side Major Row		Right Side Major Row		Right Side Lesser Row	
0	(14)	3	(5)	2	(1)	0	(9)
1	(3)	4	(12)	3	(8)	1	(10)
				4	(10)		

Combined pharyngeal tooth counts ranged from 0,0-0,0 (1 fish) to 1,4-3,1 (1 fish). Only two fish of the total sample had lesser row teeth on both right and left arches.

The low values of these counts and frequent lack of lesser row teeth is probably a result of tooth loss in these specimens. In some of the 20 specimens one or both arches appeared atrophied and lacked teeth altogether. Arches with 0-0 counts were not included above. This was most notable on the left side where three of the 20 fish completely lacked teeth. In cases where gaps occurred in the middle of a row it was apparent that teeth were missing, but this was difficult to recognize at the ends of rows or in the lesser row, which bears only one tooth. Many of the arches had apparently lost bone to such an extent that no pits indicating positions of lost teeth were evident. Regardless of the reason for atypical counts, it should be recognized that this species in Manitoba may often have only one row of pharyngeal teeth on each side, a condition not previously reported for this species.

Carpiodes cyprinus, QUILLBACK: Quillback were first collected by Environment Canada from the Red River in 1974. In 1980, they were collected at a site just downstream from the Red River Floodway Control Gate, south of Winnipeg. The water in the Red River is turbid. Current velocities are faster at the floodway locality (about 1 m/sec) than typical for the Red River. The addition of fill associated with construction of the floodway control gate has produced a rocky bottom consisting of poorly sorted material ranging from fine gravel up to large boulders instead of the clay-silt sediments found in most Red River localities. Juvenile Quillback are most commonly collected at this locality, but a few larger specimens have also been taken.

Ictiobus cyprinellus, BIGMOUTH BUFFALO: This species was caught in hoop nets on rare occasions,

along with Carp and Quillback, at the mouth of the Cram Creek, Delta Marsh in the summers of 1982 and 1983 (G. Lapointe, personal communication 1983) (Table I) and a male in spawning condition was obtained in May, 1983. It has previously been found rarely in the Red, Assiniboine near its junction with the Red, and Qu'Appelle rivers in Manitoba (Scott and Crossman 1979). No juveniles have been caught at Delta Marsh despite extensive trap-netting in 1983.

Moxostoma macrolepidotum, SHORTHEAD REDHORSE: This species was first collected from the Assiniboine River in 1981 from three closely spaced localities in Spruce Woods Provincial Park. All had current velocities ranging from 0.5 to 1.5 m/sec. The maximum depth at each collection locality was 1.5 m, with a bottom consisting of shale gravel with an interstitial fill of silt. All the Shorthead Redhorse collected from this area to date have been larger juveniles (10 cm) or adult-sized fish.

Ictalurus melas, BLACK BULLHEAD: This species first appeared in Delta Marsh in 1974 and is now abundant there. Large schools of fry have been observed in mid to late summer since then (Stewart and Lindsey 1983). We have examined samples of *Ictalurus* fry from Delta and found only *I. melas. I. nebulosus* may also occur there, but we have not found any specimens to date. Black Bullheads are abundant and widespread in the Assiniboine and Red rivers, preferring warm, quiet weedy backwaters like those afforded by Delta Marsh.

Noturus flavus, STONECAT: Two Stonecats were collected from the Assiniboine River in Spruce Woods Provincial Park, during the summer of 1982, and four at Brandon during the summer of 1983. These are the first known occurrences of this species west of the Red River. The specimens from Spruce Woods Provincial Park were taken from a shallow ($\leqslant$10 cm) riffle with a shale bottom.

Noturus gyrinus, TADPOLE MADTOM: This species was collected at three new Manitoba localities; Kichie Manitou Lake in Spruce Woods Provincial Park, the Assiniboine River at Brandon, and at Delta Marsh (Table 1). This species has not been recorded previously from the Assiniboine River or Lake Manitoba, the nearest localities being the Red River and Lake Winnipeg in Manitoba and the Souris River in Saskatchewan. It is not common in any of the new localities, but Kichie Manitou Lake and Delta Marsh both yielded specimens ranging from small juveniles to adult-sized fish, suggesting that Tadpole Madtoms reproduce in both of those areas.

Fundulus diaphanus, BANDED KILLIFISH: One Banded Killifish was collected from the south arm of Crowduck Lake. The specimen was found near a wild rice stand in 1.0 – 2.0 m of clear water with a sand/silt bottom, similar to the preferred habitat described for the species by Scott and Crossman (1979).

Morone chrysops, WHITE BASS: One small specimen was collected from the Red River at Winnipeg in 1974, and since 1981, several small specimens have been collected from the Red River at the Floodway Control Gate south of Winnipeg. Physical conditions in this locality were described previously for the Quillback collections.

Pomoxis annularis, WHITE CRAPPIE: One White Crappie was collected in 1982 from the Red River at the Floodway Control Gate south of Winnipeg. The habitat is similar to that described above for Quillback. The specimen was smaller (Table 2) than that of Age 1, White Crappies reported by Scott and Crossman (1979). While growth of this species in Manitoba may be slower than that of more southerly populations, it remains likely that the Manitoba specimen is a young-of-the-year or Age 1 fish.

Discussion

Range Extensions Not Involving Lake Manitoba

The Bigmouth Shiner occurs abundantly in the Pembina River, from its crossing of Provincial Highway 31, downstream (southeast) to the Manitoba-North Dakota border (49°00′ – 49°05′N, 98°21′W). It has also been identified in a collection from the Woody River (52°31′N, 100°51′W) made on 12 August 1955 (ROM 18744, 8 specimens), and has been collected in the Souris River in North Dakota (Owen, et al. 1981). The species is easily confused with the Sand Shiner, *Notropis stramineus*, which is common in much of southern Manitoba from the Red River westward. Only twelve Bigmouth Shiners have been found in Assiniboine River drainage collections in the area between Spruce Woods Provincial Park and Brandon since 1973, indicating that the species is rare there. Since close examination is required to distinguish it from the Sand Shiner, it probably goes unrecognized most of the time.

Blackchin Shiners were first recognized in Manitoba from the collection made in Oak Creek in 1973, but that collection has not been reported anywhere up to now. During summer, 1982, the species was collected from Dauphin Lake, and from two oxbows of the Assiniboine River in Spruce Woods Provincial Park.

Blackchin Shiners have apparently been in the Assiniboine River drainage in the Spruce Woods Provincial Park area for some time. This is supported by the 1973 collection which was made about 48 km (by river) upstream from the Assiniboine oxbow collec-

tions we made in 1982. The Dauphin Lake drainage has no direct connection with the Assiniboine River drainage, so the species also could not have moved naturally from either drainage to the other in a relatively short time.

Except for these Manitoba localities, the only other known Hudson Bay drainage occurrence of this species is in Red River tributaries in Northwestern Minnesota (Eddy and Underhill 1974; Owen et al. 1981). It does not seem likely that introduction by man could account for the scattered occurrence of this species in Manitoba. Most likely, it entered Manitoba naturally and survives in areas of suitable habitat. Because it closely resembles the Blacknose Shiner, *Notropis heterolepis*, which is widespread in southern and central Manitoba, it could have gone unrecognized until now.

The natural distribution of the White Crappie did not include the Hudson Bay drainage (Scott and Crossman 1979; Lee et al. 1980). The species has appeared, apparently by introduction, in the upper Red River (Bailey and Allum 1962), Sheyenne River (Wilson 1950; Copes 1965), and perhaps in the Souris River loop in North Dakota (Owen et al 1981). The present record constitutes the first for the species in the Manitoba portion of the Red River, and represents the most northwesterly known occurrence of the species.

The White Crappie is most likely in the initial stage of spreading downstream in the Red River, and at present occurs only rarely in Manitoba. The fact that the Manitoba specimen is a young-of-the-year, or, at most, Age 1 fish, indicates that this individual was probably hatched from eggs spawned in Manitoba, and is not a downstream migrant from the USA. A related species, the Black Crappie, *Pomoxis nigromaculatus*, occurs rarely in the Red River and Lake Winnipeg as an introduced species. One small specimen was taken in the same collection as the White Crappie. If the limited success of the Black Crappie provides a valid comparison, then it is likely that the White Crappie will never become widespread or abundant in Manitoba.

The appearance of Quillback and White Bass in the Red River suggests relatively recent spreading and/or increase in abundance of these species upstream from Lake Winnipeg. Neither species had been found above Lake Winnipeg before 1974, despite frequent collections by the University of Manitoba and Manitoba Department of Natural Resources. Both species have been taken from the Sheyenne River in North Dakota, which is part of the Red River drainage.

The occurrence of Quillback, White Bass and White Crappie at the same location in the Red River near the Floodway Control Gate probably reflects some or all of the following factors: (1) The abrupt change in water velocity and/or substrate type may constitute a partial barrier to fish movement, causing transient fish to hold in that area. (2) The relatively unusual habitat type may be better suited to some species than most of the Red River. (3) Fish collections have been made there more frequently and at more regular intervals than in other Red River localities.

The westward range extensions of the Mudminnow, Shorthead Redhorse, Stonecat, and Tadpole Madtom into the Assiniboine River at Spruce Woods Provincial Park and Brandon probably reflects, in part, the lack of collecting effort in this area up to now. Shorthead Redhorse and Tadpole Madtom are known from further upstream in the Qu'Appelle and Souris Rivers, respectively, in Saskatchewan.

The Stonecat provides the best evidence for a real extension of range and increase in abundance. They were first recorded in Manitoba from the Red River near Winnipeg in 1969 (Stewart and Lindsey 1970). While, at that time, the species seemed restricted to one locality where it was uncommon, it has been collected since then in increasing numbers both upstream and downstream of the original Red River locality, and in the lower reaches of some Red River tributaries in eastern Manitoba.

The single specimen of Banded Killifish collected at Crowduck Lake constitutes the second collection of this species in Manitoba. The first was from the Red River at Winnipeg (Stewart-Hay 1954). Although this report is the first for the species in the Manitoba portion of the Winnipeg River drainage, Foote (personal communication, 1982) collected several specimens from Lake of the Woods, Ontario, in 1981. Killifish are also known from the Sheyenne and Turtle rivers in North Dakota (Red River drainage) and from Red River tributaries in Northwestern Minnesota (Owen et al. 1981). This species is probably extremely rare in Manitoba since it has otherwise not been found despite frequent collecting efforts in southeastern Manitoba and the presence of a commercial minnow fishery on the lower Red River and in Lake Winnipeg.

Drainage History, the Assiniboine River Floodway and Fish Dispersal

The postglacial history of Lake Manitoba was discussed by Teller and Last (1981). Between the final recession of Glacial Lake Agassiz and about 4500 BP, the Assiniboine River drained eastward into the present Red River/Lake Winnipeg area. Between 4500 and about 2200 BP, however, it drained to the north, flowing into the south end of Lake Manitoba via the present Blind Channel in Delta Marsh (Figure 1). Lake Manitoba, in turn, drained into Sturgeon Bay,

TABLE 2. Morphological data for specimens examined from new localities. Symbols and abbreviations as follows: L.L. scales — Scales in lateral line (or lateral scale rows, if lateral line incomplete or missing); TL — Total length; NR — Not recorded; R — range of values for that character; * — Data include specimens from Delta Marsh only for that species; For all counts, values for counts are to the left and number of specimens showing each value is to the right, in parentheses.

Species	L.L. Scales	Dorsal Spines	Dorsal Rays	Anal Spines	Anal Rays	Gill Rakers Upper Limb	Gill Rakers Lower Limb	TL mm	Depth % TL	Head Length % TL	Eye Diameter % TL	Snout Length % TL	Longest Gill Raker % TL
Umbra limi Central Mudminnow*	34 (2) 35 (3) 36 (1) 37 (2)	—	13 (2) 14 (4) 15 (2)	—	8 (2) 9 (6)	4 (7) 5 (1)	8 (5) 9 (2) 11 (1)	x 96.9 R 79–130	18.8 18.1–20.7	24.7 24.3–25.6	4.6 4.2–5.3	5.5 4.8–5.8	1.1 0.9–1.3
Notropis dorsalis Bigmouth Shiner	39 (2)	—	7 (2)	—	8 (2)	NR	NR	x 59.1 R 54.6–63.5	15.5 14.8–16.1	22.1 21.7–22.5	6.0 6.0	7.1 6.6–7.6	NR NR
Notropis heterodon Blackchin Shiner	33 (1) 34 (7) 35 (3) 36 (6) 37 (3)	—	7 (8) 8 (12)	—	7 (8) 8 (12)	NR	NR	x 47.1 R 28.5–47.5	18.2 16.2–19.5	22.0 19.4–27.7	7.8 6.8–8.9	5.5 3.5–6.8	NR NR
Carpiodes cyprinus Quillback	38 (3) 29 (1) 41 (1)	—	25 (1) 27 (1) 28 (1) 29 (1) 30 (1)	—	7 (5)	(Total Gill Rakers)	31 (1) 34 (1) 36 (2) 37 (1)	x 191.2 R 149–253	28.3 27.3–29.4	20.6 19.5–21.7	4.6 4.3–5.1	6.0 5.4–6.8	2.3 2.0–2.7
Ictiobus cyprinellus Bigmouth Buffalo*	38 (1)	—	28 (1)	—	10 (1)	(Total Gill Rakers)	62 (1)	530	29.3	24.5	2.9	7.0	2.6
Moxostoma macrolepidotum Shorthead Redhorse	43 (1) 44 (1) 45 (1) 46 (2)	—	12 (3) 13 (2)	—	7 (5)	(Total Gill Rakers)	18 (1) 19 (2) 22 (1) 23 (1)	x 164.6 R 151–189	21.0 20.1–21.7	18.7 18.2–19.2	4.7 4.3–5.3	8.1 7.6–8.6	1.3 1.2–1.4
Ictalurus melas Black Bullhead*	—	I (8)	6 (6) 7 (2)	—	17 (1) 18 (5) 20 (1) 21 (1)	4 (1) 5 (7)	11 (1) 12 (3) 13 (4)	x 183.3 R 135–250	23.3 20.6–25.5	26.9 26.3–28.5	3.4 2.9–4.1	10.3 9.1–11.8	1.8 1.5–2.0
Noturus flavus Stonecat	—	I (1)	6 (1)	—	15 (1)	1 (1)	4 (1)	73.0	14.3	22.5	3.4	8.9	NR
Noturus gyrinus Tadpole Madtom*	—	I (3)	6 (3)	—	14 (1) 15 (2)	1 (3)	6 (1) 7 (2)	x 56.3 R 38.0–84.0	19.5 17.6–22.9	22.9 22.1–23.4	3.6 3.0–4.3	9.3 8.2–10.6	NR
Fundulus diaphanus Banded Killifish	42 (1)	—	13 (1)	—	11 (1)	NR	NR	77.0	17.0	22.1	6.5	6.0	NR
Morone chrysops White Bass	52 (3) 53 (1) 55 (1)	IX: I (4)	13 (3) 14 (2)	III (5)	12 (4) 13 (1)	6 (3) 7 (1) 8 (1)	12 (1) 13 (2) 14 (2)	x 98.5 R 93–112	27.6 25.9–28.3	27.3 26.2–28.2	6.9 6.5–7.1	6.5 5.9–7.0	3.9 3.7 4.1
Pomoxis annularis White Crappie	35 (1)	VI (1)	14 (1)	VI (1)	18 (1)	NR	NR	45.4	23.3	27.8	7.7	6.6	NR

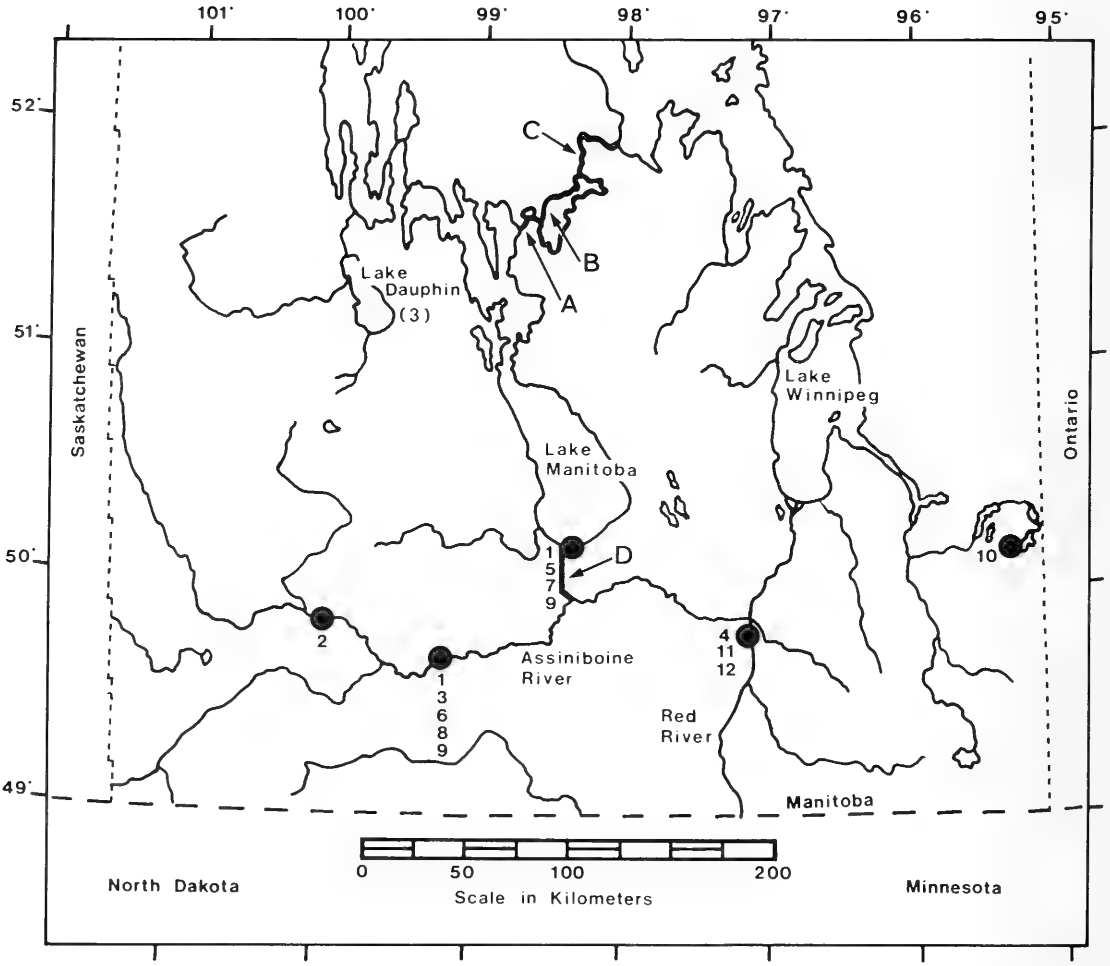

FIGURE 1. Map of southern Manitoba, showing collecting localities (solid circles), and possible dispersal routes (heavy lines and letters A-D) for fish, connecting Lake Manitoba with the Red and Assiniboine Rivers and Lake Winnipeg. Numbers associated with each collecting locality signify species reported in this paper as follows: 1 *Umbra limi,* 2 *Notropis dorsalis,* 3 *N. heterodon* (Babaluk and Harbicht 1984) 4 *Carpiodes cyprinus,* 5 *Ictiobus cyprinellus,* 6 *Moxostoma macrolepidotum,* 7 *Ictalurus melas,* 8 *Noturus flavus,* 9 *Noturus gyrinus,* 10 *Fundulus diaphanus,* 11 *Morone chrysops,* 12 *Pomoxis annularis.* Letters denote interconnections between Lake Manitoba and the Red River/Assiniboine River/Lake Winnipeg system as follows: A) Fairford River; B) Lake St. Martin; C) Dauphin River; together these have been the natural outflow channel from Lake Manitoba to Lake Winnipeg since about 2000 yr BP; D) Assiniboine River Floodway, a man-made outfall channel which carries Assiniboine River water into Lake Manitoba during flooding.

Lake Winnipeg (51°58′N) via the present Fairford River, Lake St. Martin and Dauphin River. After about 2600 BP, the Assiniboine began to adopt its present course, entering the Red River at the location of Winnipeg. Since 2000 BP, then, the only continuous water connection between the Red River and Lake Manitoba has been by crossing a minimum linear distance of about 200 km of open lacustrine habitat in Lake Winnipeg in order to reach the Dauphin River. This has apparently been an effective barrier to movement of Red River fish into Lake Manitoba. This is supported by the fact that, until 1974, there were only two isolated records of any of the five catfish species in the Red River having occurred in Lake Manitoba. A Channel Catfish (*Ictalurus punctatus*) was recorded from the commercial fishery in 1945

and a single Tadpole Madtom collected in Delta Marsh by a high school class in the summer of 1973 (J. H. Gee, personal communication, 1983). Neither record is supported by a specimen. The Channel Catfish may be an erroneous locality report of a Lake Winnipeg fish, since the species is common there. The Tadpole Madtom was probably correctly identified, but was found after the Assiniboine Floodway had operated for three years.

The Assiniboine River Floodway just west of Portage la Prairie, diverts floodwater from the Assiniboine River 25 km north into Lake Manitoba near Delta (Figure 1). The floodway was first operational for 18 days in the spring of 1970, 9 days in 1971 and 41 days in 1972, channelling water into Lake Manitoba from the Assiniboine River for the first time in about 2000 years. In 1974 and 1976 the west dike of the floodway was opened near the Blind Channel, allowing excess floodwater to flow directly into Delta Marsh. It should be noted that Delta Marsh and the southern end of Lake Manitoba have been regularly collected by University of Manitoba and Manitoba government personnel since 1967.

Prior to 1974, the two isolated records discussed above were the only evidence of the occurrence in Lake Manitoba of any Red or Assiniboine river species not long-documented from there. Lack of collecting effort does not seem to be a likely explanation.

Since 1974, large numbers of bullhead fry were recorded by a University of Manitoba ecology class and provincial biologists (J. H. Gee, personal communication, 1983). The failure of Black Bullheads to appear before floodwater was allowed to spill into the marsh, and not four years earlier when it flowed directly into Lake Manitoba, supports the contention that an open lacustrine habitat is an effective barrier to the spread of this species.

The Central Mudminnow and Tadpole Madtom were not collected at all in the Assiniboine River until the summer of 1982. Both of these species are commonly found with Black Bullhead in eastern Manitoba, but despite their rarity west of the Red River have appeared in Delta Marsh since first operation of the floodway. Bigmouth Buffalo are rare in Manitoba, but they have also appeared in Delta Marsh since the first opening of the Assiniboine Floodway.

It should be noted that Channel Catfish have been reported in Lake Manitoba with increasing frequency by anglers during the last few years, although no Lake Manitoba records of this species are supported by specimens to date. Mr. G. Lapointe (personal communication, 1983) has collected and examined specimens of this species from Lake Manitoba in 1982 and 1983.

The first appearance of four, and probably five, species of fish in Delta Marsh and Lake Manitoba within 13 years of the first operation of the Assiniboine River Floodway permits speculation about the times and routes by which they may have entered Manitoba and their subsequent dispersal.

All five species occur in the upper Mississippi River, but two, the Central Mudminnow and Tadpole Madtom, are absent from the Missouri River in North Dakota. None occur naturally in Lake Superior, although all except the Bigmouth Buffalo occur in lakes Michigan and Huron. In Manitoba, all five occur in the Red and Assiniboine rivers, but only one, the Central Mudminnow occurs in the Winnipeg River. The distribution pattern suggests that all five species entered Manitoba from the upper Mississippi River via the Red River, rather than from either the upper Missouri River or the Great Lakes.

In view of the drainage history of the Assiniboine River (Teller and Last 1981), it seems likely that none of these species could have entered Manitoba earlier than about 4500 BP. If they had, they should have been able to move into the Assiniboine from the Red River, and would have reached Lake Manitoba between 4500 and 2000 BP when the Assiniboine flowed into Lake Manitoba.

It does not seem likely that they would have been in Lake Manitoba and subsequently disappeared there, since the lake and marsh support a variety of fish species. It is difficult to conceive of conditions which would eradicate Black Bullhead or Central Mudminnow for example, while leaving species with such varied adaptations as Cisco (*Coregonus artedii*), Brook Stickleback (*Culaea inconstans*) and Quillback (*Carpiodes cyprinus*) unaffected.

The distribution patterns further suggest that all five species entered the Red River after 2000 BP. Alternatively, the shift of the Assiniboine River mouth from Lake Manitoba to the Red River was sufficiently abrupt that none of the species could have ascended the Assiniboine from a newly developed Red River connection and then moved into Lake Manitoba before that connection was completely abandoned. If the effectiveness of the Assiniboine River Floodway in transferring species is a realistic approximation of what might have occurred, the interval during which the shift occurred would have had to be on the order of 10 to 20 years. This is much shorter than the approximately 300 year span which Teller and Last (1981) estimate was required for the Assiniboine to completely abandon its Lake Manitoba outfall. Therefore, we suggest that none of the species in question entered Manitoba before about 2000 BP.

We can conclude that the range extensions reported here are probably the result of a variety of processes, not all of which are clear. *Notropis dorsalis* and *N.*

heterodon, in particular, probably escaped notice through lack of collecting effort and/or confusion with similar species. *Fundulus diaphanus* probably represents a chance find of an extremely rare and scattered species. All the others, to varying degrees, may reflect extensions of distribution, increasing abundance and increased collecting effort in the area in which they were found. The role of the Assiniboine River Floodway in providing a southern, non-lacustrine access route from the Red River to Lake Manitoba seems conclusively demonstrated. The rapid use of this route by Black Bullheads and its use even by species previously unknown in the Assiniboine River should illustrate the potential that any breach of a drainage separation has for permitting the spread of fish species. In a larger sense, all of these extensions, whether the result of natural or man-made causes, can be viewed as steps in the continuing process of dispersal of fish in Manitoba following retreat of the Wisconsinan Ice Sheet.

Acknowledgments

Brent Guinn, George Lapointe, Brent Poole, Brian Parker, Ray Ratynski, Alfred Shostak, John Stewart and Bessie Stewart all assisted us at various times in collecting and/or provided their own fish collections to us. Dr. Redman Clarke, Department of Fisheries, and Oceans, and Mr. Brian Yake, Provincial Fisheries Branch, provided collections from the Red River at Winnipeg and the Assiniboine River at Brandon respectively, for our examination. Students in the Biology of Fish class of the University of Manitoba Zoology Department also lent their efforts to fish collecting. We are grateful to Dr. John H. Gee and Mr. George Lapointe who provided us with their information and unpublished field notes. This paper is, in part, contribution no. 102 of the University of Manitoba Field Station, Delta Marsh, Manitoba.

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Received 18 January 1984
Accepted 26 September 1984

Food Habits of the Columbian Ground Squirrel, *Spermophilus columbianus*, in Southcentral Idaho

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Elliott, Charles L., and Jerran T. Flinders. 1985. Food habits of the Columbian Ground Squirrel, *Spermophilus columbianus*, in southcentral Idaho. Canadian Field-Naturalist 99(3): 327–330.

The food habits of two colonies of Columbian Ground Squirrels (*Spermophilus columbianus*) in the River of No Return Wilderness Area, Idaho, were determined. Clover (*Trifolium* spp.), Alpine Timothy (*Phleum alpinum*), and Yarrow (*Achillea millefolium*) were the important species at the mountain meadow study site. Balsamroot (*Balsamorhiza saggittata*), Bluebunch Wheatgrass (*Agropyron spicatum*), and Silky Lupine (*Lupinus sericeus*) were the major species consumed on the dry south-slope site.

Key Words: Columbian Ground Squirrel, *Spermohilus columbianus*, food habits, Idaho.

In the Pacific Northwest region of the United States members of the genus *Spermophilus* are an important component of the ecosystem. One member of this group is the Columbian Ground Squirrel (*Spermophilus columbianus*). Although limited in geographical distribution (Manville 1959), *S. columbianus* has been the subject of ecological and behavioral investigations (Shaw 1924; Steiner 1970; Betts 1974; Boag and Murie 1981), but little information concerning the squirrels dietary habits has been reported. This paper presents the results of a two-year study of the Columbian ground squirrel relative to its food habits in southcentral Idaho.

Study Area

The study was conducted in the Big Creek Ranger District, River of No Return Wilderness Area (formerly the Idaho Primitive Area). A description of the Big Creek drainage has been provided by Hornocker (1970). A preliminary examination of the region showed that Columbian Ground Squirrels generally occupied two types of habitats.

Cold Meadows (elevation 2142 m) typified the mountain meadow habitat type used by *S. columbianus*. Meadow vegetation appeared to have developed through normal processes of hydroseral succession with the soil being maintained in a saturated or near saturated condition (Wing 1969). Vegetation within the meadow exhibited a predominance of sedges with a variety of grasses and forbs. Hydromorphic and alluvial soils predominate, but sandy loams occur along the outer meadow edges (Wing 1969).

Rush Point (elevation 1890 m) represented the *Artemisia tridentata*-bunchgrass association typical of the southeast-facing slopes occupied by Columbian Ground Squirrels. The perennial dominated plant community occupies soils derived from basalt, granite, sedimentary deposits and metamorphosed variations of these materials (Mueggler and Harris 1969).

Methods

The botanical communities of the two study sites were compared using Jaccard's community coefficient (Jaccard 1912). The resulting index value of 22% indicated each site was a distinct plant community, with little similarity in species composition.

Each study area was visited according to a monthly schedule: Cold Meadows 12-19 June, 17-24 July, and 14-21 August; Rush Point 1-8 June, 1-8 July, and 1-8 August, 1977 and 1978. Squirrels were above ground and active when initial visits were made to each site. Ground squirrels were collected using live traps in 1977 and a shotgun in 1978. Samples collected during the same time period in 1977 and 1978 were pooled and a composite monthly diet determined. The development of vegetation at each site exhibited similar patterns for both years — Rush Point developing earlier than Cold Meadows.

Stomach contents were analyzed using the microhistological technique described by Flinders and Hansen (1972). No attempt was made to discern what individual plant parts (eg. stem, leaf, flower, root) were consumed. The frequency of occurrence for each dietary item identified was converted to relative density, and this value converted to percent dry weight following the calculations proposed by Sparks and Malechek (1968).

Squirrels were classified by age as adults or young of the year. No attempt was made to differentiate adults from reproductively immature animals older than young of the year. An initial criteria for separating age classes based on physical parameters (body

weight, ear length, hind foot length) from known age squirrels proved to be unreliable.

Plant biomass was determined in July of each year at each site using the calibrated weight-estimate method (Tadmor et al. 1975). Preliminary sampling in 1976 determined that 10 vegetation transects at Cold Meadows and 14 transects at Rush Point were required to be 95% certain the vegetation sample mean was within 20% of the true mean for the single most abundant plant species at each site (Subcommittee on Range Research Methods of the Agricultural Board 1962). A 50 × 50 cm sampling frame was placed every 9 m along a 90 m transect line, this size plot was used to reduce the 'edge effect' encountered when sampling in tall vegetation (Tadmor et al. 1975). Scientific nomenclature of plants follows Hitchcock and Cronquist (1973).

Results and Discussion

Biomass production did not differ greatly between years for each study site. Cold Meadows produced 1919 and 1822 kg/ha and Rush Point 1195 and 1086 kg/ha of biomass in 1977 and 1978 respectively.

A total of 296 Columbian ground squirrels were collected for dietary analysis. The determined monthly diets are depicted in Tables 1 and 2.

Clover (*Trifolium* spp.), Yarrow (*Achillea millefolium*), and Alpine Timothy (*Phleum alpinum*) were the principal food items consumed by adult squirrels in June and July at Cold Meadows (Table 1). During

TABLE 1. Relative percent dry weight of plant species comprising the monthly diets of male (M) and female (F) Columbian Ground Squirrels collected at Cold Meadows, River of No Return Wilderness Area, Idaho, 1977-78. Sample size in parentheses.

	June		July				August			
	Adult		Adult		Juvenile		Adult		Juvenile	
Species	M (23)	F (27)	M (19)	F (25)	M (7)	F (8)	M (6)	F (8)	M (12)	F (10)
Achillea millefolium	11	25	14	20	19		25	65	40	41
Erigeron speciosus	13	7	7	9	30	51	6	14	32	23
Phleum alpinum	3	8	31	16	6	4	42	7	6	21
Ranunculus alismaefolius		6	9							
Taraxacum officinale	8	5	7	6						
Trifolium spp.[1]	46	38	19	29	30	33		5		
Trisetum spicatum	2			6			12		5	
Valeriana officinalis							6			

[1]includes *Trifolium longipes* and *T. repens*.
Note: due to trace amounts (1%) and plant particles classified as unknown the columns do not total 100%.

TABLE 2. Relative percent dry weight of plant species comprising the monthly diets of male (M) and female (F) Columbian Ground Squirrels collected at Rush Point, River of No Return Wilderness Area, Idaho, 1977-78. Sample size in parentheses.

	June		July				August			
	Adult		Adult		Juvenile		Adult		Juvenile	
	M (11)	F (27)	M (22)	F (22)	M (15)	F (16)	M (8)	F (8)	M (12)	F (10)
Achillea millefolium	20	16	4	4			16	7	5	5
Agropyron spicatum	2	2	13	20	38	4	13	8	9	20
Balsamorhiza saggittata	59	56	38	54	30	53	31	39	40	20
Descurainia richardsonii					2		7			3
Festuca idahoensis		4	8		4	2	7	4	6	
Hieracium albertinum	3	5	3			4				
Lithospermum ruderale			4	4		9				
Lupinus sericeus	2	9	19	9	11	13	12	24	30	20
Machaeranthera canescens							5	4		5
Potentilla glandulosa					8			4		
Physocarpus malvaceus	4									7
Purshia tridentata						5				7

Note: due to trace amounts (1%) and plant particles classified as unknowns the columns do not total 100%.

August, Yarrow and timothy increased in the diet but clover consumption was negligible. Juvenile squirrels (= young of the year) consumed Fleabane (*Erigeron speciosus*) and clover during July and, like adults, eliminated clover from the August diet — concentrating instead on Fleabane and Yarrow.

Adult and juvenile Columbian Ground Squirrels on the Rush Point site consumed Balsamroot (*Balsamorhiza saggittata*) throughout the summer (Table 2). Bluebunch Wheatgrass (*Agropyron spicatum*) and Silky Lupine (*Lupinus sericeus*) gained additional diet importance for both age groups in July and August. Yarrow was eaten by adults in June and August but never to the same degree as was noted at Cold Meadows.

Lambeth and Hironaka (1982) determined the food habits of Columbian Ground Squirrels on central Idaho sheep ranges. Silky Lupine was the most heavily used species, constituting 29% of the diet; sedges and grasses contributed 9 and 12% respectively. In addition to Silky Lupine, Tansy Mustard (*Descurainia richardsonii*) and Yarrow were preferred by ground squirrels but not by domestic sheep (*Ovis* spp.).

Many of the plant species which comprised minor items in the squirrel diets at both study locations were not encountered in the biomass sampling. Preference indices could not be computed for these diet components, but the major species consumed by the squirrels also comprised the bulk of biomass collected. Preference indices were computed for the major diet items using the procedure described by Hansen and Ueckert (1970). No plant species exhibited a preference value greater than one, indicating the major items in the diet were being consumed as they were encountered in the field. Insufficient data was available to determine if minor items in the diet were being sought out and selectively consumed. Comparison of the seasonal diets of adult Columbian Ground Squirrels versus juveniles indicates a high degree of dietary similarity (Table 1 and 2), but some dietary differences between age groups and sexes do exist (eg. juvenile use of Fleabane at Cold Meadows).

Columbian Ground Squirrels are hibernators, depending on the fat accumulated during the summer to sustain them while inactive. The inability to acquire sufficient fat stores before hibernating has been postulated to be a cause of over-winter mortality (Shaw 1926). The optimal foraging theory assumes that the fitness associated with an animals foraging behavior has been maximized by natural selection (Pyke et al. 1977). One of the basic arguments of the theory is that behavior in general, and foraging behavior in particular, shows heritable variation; and this entails variation in the contribution to subsequent generations.

The variation in dietary groups consumed by Columbian Ground Squirrels from different geographical locations may be a reflection of the seasonal nutritional composition of the available forage (ie. lack of sedge in diets in this study versus 9% of diet in Lambeth and Hironaka's (1982) study). The dietary variation observed between sexes and age groups in this study may have also been an expression of the nutritional levels of the forage, with juveniles concentrating on plants particularly high in nutrients to enhance their individual weight gain and over-winter survivability. If this is the case, is this observed juvenile foraging behavior the result of heritable variation (as postulated in the optimum foraging theory)? More studies and more information incorporating diets, forage nutrient composition and foraging behavioral studies (incorporating both different sex and aged individuals) of Columbian Ground Squirrels in different geographical settings are needed in order to help clarify the relationship between diet variation and foraging behavior.

Acknowledgments

We thank the University of Idaho's Wilderness Research Committee for permission to use the facilities at the Taylor Ranch Field Station, River of No Return Wilderness Area. This article is especially dedicated to the late Mr. Arlow Lewis.

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Received 26 August 1983
Accepted 27 September 1984

Dispersal of White-footed Mice, *Peromyscus leucopus*, in Low-density Island and Mainland Populations

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Adler, Gregory H., and Robert H. Tamarin. 1985. Dispersal of White-footed Mice, *Peromyscus leucopus*, in low-density island and mainland populations. Canadian Field-Naturalist 99(3): 331–336.

Demographic attributes of dispersing White-Footed Mice, *Peromyscus leucopus*, on Muskeget Island, Massachusetts, and the adjacent mainland were compared. Densities of both populations were low throughout the five years of study. The number of dispersers was positively correlated with the number of residents in both populations, but the rate of dispersal was not related to the density of the resident populations. Dispersers of both sexes on Muskeget reached sexual maturity at a lower weight than residents. On the mainland, male dispersers reached sexual maturity at a lower weight than residents, whereas female dispersers reached sexual maturity at a greater weight than residents. A greater number of young females dispersed on Muskeget than expected, whereas more young males dispersed than expected on the mainland. Adult males may have been important in limiting recruitment on the mainland but not on Muskeget Island. We hypothesize that there is a relationship between the roles of males and females in limiting recruitment and the relative positions of *Peromyscus* populations on the r and K selection continuum.

Key Words: demography, dispersal, Massachusetts, *Peromyscus leucopus*, r and K selection, White-footed Mouse.

Dispersal has been found to be important in the demography of small mammal populations (reviewed by Lidicker 1975; Gaines and McClenaghan 1980; Tamarin 1980). Experimental studies of dispersal have been conducted on a number of species of small mammals including members of the genera *Clethrionomys* (Kozakiewicz 1976), *Geomys* (Williams and Cameron 1984), *Microtus* (Myers and Krebs 1971; Krebs et al. 1976; Tamarin 1977a; Krebs et al. 1978; Beacham 1979; Gaines, Baker and Vivas, 1979; Keith and Tamarin 1981; Baird and Birney 1982a, 1982b; Gaines and Johnson 1984), *Peromyscus* (Garten and Smith 1974; Sullivan 1977; Fairbairn 1977a, 1978a; Nadeau et al. 1981; King 1983), *Reithrodontomys* (Joule and Cameron 1975), *Sigmodon* (Joule and Cameron 1975; Stafford and Stout 1983), and *Synaptomys* (Gaines, Vivas and Baker 1979). Studies of island populations generally show that dispersal is reduced in these populations (Mazurkiewicz and Rajska 1975; Sullivan 1977; Tamarin 1977a).

Nadeau et al. (1981) analyzed dispersal of White-footed Mice, *Peromyscus leucopus*, in relation to population structure on Muskeget Island, Massachusetts, and concluded that males did not limit recruitment or determine population structure, in contrast to most other population studies of *Peromyscus*. Adler and Tamarin (1984) compared demographic and reproductive attributes of the White-footed Mouse on Muskeget Island and on the adjacent mainland and found important differences in several attributes. If dispersal is closely linked to demography, then we would expect to find important differences in the process of dispersal on Muskeget Island and the mainland. In this study, we compared demographic attributes of dispersing White-footed Mice on Muskeget Island and the adjacent mainland.

Materials and Methods

Muskeget Island is a small sandy island located 32 km south of Cape Cod, Massachusetts. The habitat of Muskeget is dominated by Beach Grass (*Ammophila breviligulata*) and Poison Ivy (*Rhus radicans*).

Two 0.8 ha control grids (grids A and B of Tamarin, 1977b) were established to monitor residents on Muskeget. Both grids consisted of a 10 × 10 matrix of trap stations with 7.6 m between stations. One Longworth live-trap baited with oats and supplied with cotton for bedding occupied each station. Traps were set for two consecutive nights and checked the following mornings. Trapping was conducted approximately monthly.

Captured mice were ear-tagged with fingerling fish tags, sexed, and weighed. Reproductive data were recorded and consisted of position of the testes (scrotal or abdominal) in males and vaginal patency and nipple size in females. Obvious pregnancies were detected by palpation. Mice were released at their point of capture after data were recorded.

A 0.8 ha experimental grid (grid E of Tamarin 1977a) was established 30.4 m from grid B to collect dispersers. Mice captured during the first trapping period were considered residents and permanently removed. All mice colonizing the grid after the initial removal period were considered dispersers and were permanently removed during every subsequent trapping period. Data were gathered on dispersers in a

manner similar to residents, but dispersers were sacrificed and returned to the laboratory for autopsy.

A similar trapping design was followed on the mainland. The control grids (grids D and F of Tamarin 1977b) were located in Barnstable and Plymouth, Massachusetts, respectively. Both grids were dominated by the grass *Poa pratensis*. The removal grid (grid G of Tamarin 1977a) was located 30.4 m away from grid F. Grid G was rectangular. The first 8 lines nearest grid F were 8 stations long and the last 4 lines were 9 stations long.

Trapping on Muskeget began in May 1972 and was continued until August 1977. Trapping at Barnstable began in June 1972 and was terminated in January 1976 and trapping began at Plymouth in October 1972 and continued until July 1977.

We used the age classes of Adler and Tamarin (1984). Because of the small numbers of juveniles and subadults captured, we combined these two age classes together as young.

Results

Dispersal and Density

Density changes on Muskeget were described by Nadeau et al. (1981) and Adler and Tamarin (1984). Density changes on the mainland were described by Adler and Tamarin (1984). Density changes in both populations were characterized by an annual cycle in numbers with densities highest in autumn and winter and lowest in spring.

To determine the relation of dispersal to density, we calculated the total number of mice caught per 100 trapnights in each season (winter, spring, summer, and autumn) on the two control grids combined and the removal grid at each site (Figures 1 and 2). Total trapnights varied from 600 to 1200 per season on the two control grids combined at each site and from 200 to 600 per season on the removal grids at each site.

To determine if density was an important determinant of dispersal, we regressed number of dispersers on number of residents calculated in each three-month period (N = 20 periods on the mainland and 21 periods on Muskeget). Both regressions were statistically significant. On the mainland, 37.9% of the variation in the number of dispersers was explained by the density on the control grids ($F = 10.98$, $p < 0.005$), whereas 74.0% of the variation in dispersal was explained by density of residents on Muskeget ($F = 53.94$, $p < 0.001$).

To further analyze the relation of dispersal to density, we calculated recovery ratios (Krebs et al. 1976) for each season. The recovery ratio is a dispersal rate and is defined as (the number of dispersers at time t)/(the number of residents at time t). The overall recov-

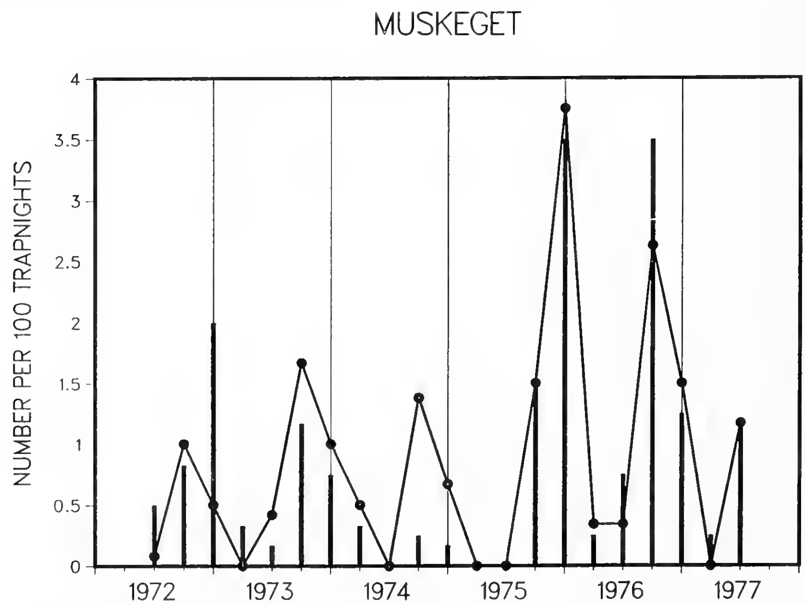

FIGURE 1. Seasonal density estimates of resident and dispersing White-footed Mice on Muskeget Island.
The solid dots connected by lines indicate the number of residents.
The solid vertical bars represent the number of dispersers.
Vertical lines separate years.

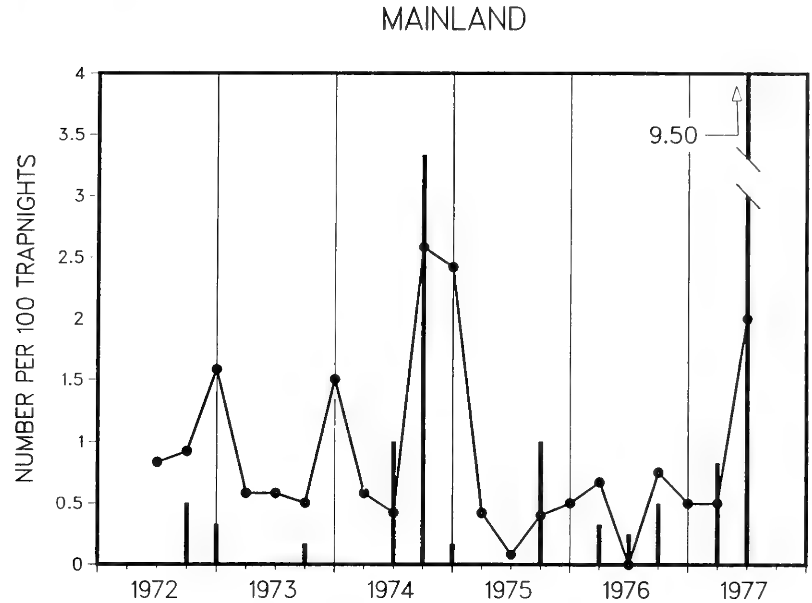

FIGURE 2. Seasonal density estimates of resident and dispersing White-footed Mice on the mainland. See legend for Figure 1.

ery ratio was 1.22 on the mainland and 1.01 on Muskeget. The last period on the mainland was characterized by an unusually high number of dispersers (9.50 per 100 trapnights). With this last period on the mainland omitted, the overall recovery ratio was only 0.66. To determine if dispersal rate was dependent upon density, we regressed dispersal rate on density. Dispersal rate was density-independent in both populations ($F = 0.27$, $p > 0.25$ for the Muskeget population; $F = 1.97$, $p > 0.10$ for the mainland population).

Thus, dispersal was correlated with density in both populations, dispersal rate was nearly twice as high on Muskeget as on the mainland (with the one period characterized by the high number of dispersers on the mainland omitted), and the rate of dispersal was density-independent in both populations.

Dispersal and Population Structure

Nadeau et al. (1981) found no differences in sex ratios (males/female) between dispersers and residents. Similarly, we found no differences in sex ratios between dispersers and residents in the mainland population (resident sex ratio = 0.81, N = 136; disperser sex ratio = 1.34, N = 68; $\chi^2 = 2.83$, $p >= 0.05$).

We compared the numbers of adult and young residents and dispersers in both populations (Tables 1 and 2). In the mainland population, more young males dispersed than expected, and on Muskeget more young females dispersed than expected.

Female dispersers weighed less than residents, but dispersing males were similar in weight to resident males on Muskeget (Nadeau et al. 1981). We found dispersing males to be lighter in weight than resident males in the mainland population ($F = 5.10$, $p < 0.025$), but we found no differences between females. Thus, the lower weights of female dispersers

TABLE 1. Numbers of adult and young residents and dispersers in the mainland population of White-footed Mice.

		Adults	Young	Chi-square
Males	Residents	54	7	10.37*
	Dispersers	24	15	
Females	Residents	47	28	1.79
	Dispersers	14	15	

*$p < 0.005$

TABLE 2. Numbers of adult and young residents and dispersers in the Muskeget Island population of White-footed Mice.

		Adults	Young	Chi-square
Males	Residents	67	26	0.53
	Dispersers	32	9	
Females	Residents	37	14	4.85*
	Dispersers	15	16	

*$p < 0.05$

TABLE 3. Median weights at sexual maturity for resident and dispersing White-footed Mice. 95% confidence intervals are in parentheses.

		Residents	Dispersers
Muskeget	Males	14.06 (8.90–22.23)	12.96 (5.83–28.78)
	Females	13.15 (9.11–18.99)	12.01 (6.09–21.56)
Mainland	Males	23.10 (18.19–29.34)	20.43 (17.29–24.13)
	Females	18.15 (16.26–20.26)	25.07 (16.98–37.00)

on Muskeget were due to a higher proportion of young females dispersing than expected, and the lower weights of male dispersers on the mainland were due to a higher proportion of young males dispersing than expected.

Dispersal and Reproduction

No differences in breeding condition between male residents and dispersers on Muskeget were found, but females were more likely to have perforate vaginae and small lactation tissue (Nadeau et al. 1981). We found no differences in reproductive condition between residents and dispersers in either males or females on the mainland.

We calculated median weights at sexual maturity for male and female residents and dispersers in the two study populations using the probit technique of Leslie et al. (1945) (Table 3). Only data from breeding seasons were used, and these data were pooled over the entire study period. Obviously pregnant females were excluded from the analysis.

Male and female dispersers on Muskeget had slightly lower median weights at sexual maturity than residents. On the mainland, male dispersers had lower median weights than residents whereas female dispersers had higher median weights at sexual maturity than residents.

Discussion

The White-footed Mouse is widely distributed in the eastern United States and southern Canada. Although it is primarily a woodland species (Baker 1968), Adler and Tamarin (1984) reported resident populations of White-footed Mice in grasslands of Muskeget Island and adjacent mainland Massachusetts. This situation has allowed a comparative study of dispersal in this species in similar habitats.

The removal grid has been widely employed in monitoring dispersal (reviewed by Gaines and McClenaghan 1980). However, mice defined as dispersers in our study may simply have been neighboring mice expanding or shifting their home ranges into a depopulated area. If this explanation were true, then the removal of mice on the experimental grid may have affected the demography of mice on the adjacent control grid. Several studies have examined the effects of depopulated areas on adjacent residents. Hayne (1949), Van Vleck (1968), and Tamarin (1977a) found no effects of removal trapping on home ranges of adjacent resident *Microtus pennsylvanicus.* Baird and Birney (1982b) provided evidence that vacant habitat was filled more by *M. pennsylvanicus* moving long distances and by juveniles than by residents expanding their home ranges. Calhoun and Webb (1953) similarly found no effects of depletion trapping on home ranges of *Blarina, Sorex, Peromyscus,* and *Clethrionomys.* Stickel (1946) found a movement of resident *Peromyscus* into depopulated areas. Tamarin (1977a) found a statistically significant movement of *Microtus breweri* toward a removal grid. Mares et al. (1980) also found a movement of nearby *Tamias striatus* into a depopulated area. However, most migrating *Tamias* individuals were juveniles which presumably left due to social pressure from adults. Thus, vacant areas had apparently little effect on movements of adult *Tamias* residents.

Three separate lines of evidence suggest that the removal grids had little effect on the demography of *Peromyscus* on the control grids in our study. First, 13% and 18% of the mice recovered from the mainland and Muskeget removal grids, respectively, were expected to have been tagged on the control grids (Tamarin 1977a). However, only 6% of the mice on the mainland grid F moved to grid G, and only 13% of the mice on Muskeget grid B moved to grid E.

Second, if mice were shifting their home ranges in response to the vacant removal area, then mice on the control grid should simply have moved short distances to the removal grid. Although sample sizes were insufficient in our study to provide a proper analysis, data from two other *Peromyscus* populations in southeastern Massachusetts indicated that distance was not important in the movement of mice onto removal grids, whereas habitat characteristics were important (Adler ms.). Adler (ms.) hypothesized that these *Peromyscus* individuals left the control grids in response to social pressure or resource limita-

tion and then sought similar habitat on the vacant removal grids.

Third, our analysis of dispersal in relation to population density and structure was consistent with studies of other small mammal populations using similar techniques (reviewed by Gaines and McClenaghan 1980). In general, the numbers of individuals dispersing have been found to be positively correlated with the numbers of residents whereas the rate of dispersal has been found to have no relationship with the numbers of residents. Most studies of dispersal in small mammals have demonstrated the tendency for younger animals to disperse more than older individuals (Gaines and McClenaghan 1980). We found a similar tendency for younger individuals to disperse in both populations. However, it was within this younger segment of the dispersing samples that we found the most important differences between the island and mainland populations. In the Muskeget Island population, dispersal was associated with immature females more than immature males, whereas in the mainland population immature males were more likely to disperse than immature females.

Fairbairn (1978a) hypothesized that the preponderance of dispersing *Peromyscus* did so due to social pressures from residents or to low resource levels. Since young individuals dominated the disperser samples in both of our study populations, it is likely that dispersers were social subordinates.

Most studies of *Peromyscus* populations showed that males limited recruitment and determined population structure (Healey 1967; Petticrew and Sadlier 1974; Fairbairn 1977a, 1978a, 1978b). However, three studies suggested that males had little effect in determining population structure (Metzgar 1971; Harland et al. 1979; Nadeau et al. 1981). Our results indicated that the mainland population was more similar to the majority of *Peromyscus* populations studied since young males were overrepresented in the disperser sample. Thus, adult male *Peromyscus* on the mainland may have led to the dispersal of subordinate males (Howard 1949; Sadlier 1965; Healey 1967; Fordham 1971; Garten and Smith 1974; Petticrew and Sadlier 1974; Fairbairn 1977a, 1977b, 1978a, 1978b; Mihok 1979).

Adler and Tamarin (1984) noted differences in demography and reproduction between the Muskeget Island and mainland populations which indicated the mainland population was more K-selected. Nadeau et al. (1981) hypothesized that the roles of males and females in limiting recruitment and densities in *Peromyscus* populations may differ. We hypothesize that there is a relationship between the role of males and females in limiting recruitment and the relative positions of *Peromyscus* populations along the r and K selection continuum.

Acknowledgments

Don Little provided facilities and permission to work on Muskeget. This study was supported by grants from the National Institutes of Health (HD-06621) and the Boston University Graduate School to RHT.

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Received 19 January 1984
Accepted 4 October 1984

Spring and Summer Distribution, Status, and Nesting Ecology of the Arctic Loon, *Gavia arctica*, in Interior British Columbia

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Campbell, R. Wayne, Brigitta M. Van Der Raay, Ian Robertson, and Brian J. Petrar. 1985. Spring and summer distribution, status, and nesting ecology of the Arctic Loon, *Gavia arctica*, in interior British Columbia. Canadian Field-Naturalist 99(3): 337-342.

Spring and summer records of the Arctic Loon (*Gavia arctica*) in interior British Columbia from 1924 to 1983 indicate this species remains a casual transient in the province south of latitude 54° North. Farther north it is now known to be a rare summer resident with small breeding populations in three disjunct areas in the province. Details of the loon's breeding and nesting sites, clutch size and egg-laying period are also discussed.

Key Words: Arctic Loon, *Gavia arctica*, British Columbia, distribution, status, nesting ecology.

In North America the Arctic Loon (*Gavia arctica*) breeds throughout the tundra and taiga regions of the western Arctic from the coasts of Alaska and Canada south to southern Alaska and southwestern Yukon (A.O.U. 1983). Farther inland the range extends into northern Ontario, Manitoba and Saskatchewan (Godfrey 1966) and recently Alberta (Hohn 1972). In winter Arctic Loons are commonly found along the Pacific Coast from the Gulf of Alaska to Baja California (Palmer 1962).

In British Columbia the Arctic Loon is an abundant spring and fall migrant in coastal areas, but is less common as a winter visitant (Munro and Cowan 1947). The main spring movement begins in late April and peaks in mid-May, and the fall movement occurs mostly in late September and October (Campbell et al. 1972; Hatler et al. 1978). Non-breeding birds summer, in small numbers, along the entire coast.

Very little is known, however, about the summer occurrence and distribution of Arctic Loons in interior British Columbia. Godfrey (1966) considered the species a "scarce transient in the southern interior" of the province. Prior to 1966, there were only four documented inland spring and summer records: Atlin in 1924 (Swarth 1930), Tetana Lake from 1938-41 (Stanwell-Fletcher and Stanwell-Fletcher 1943), Swan Lake, Peace River in 1938 (Cowan 1939), and Okanagan Lake in 1942 (Munro and Cowan 1947). Both Godfrey (1966), and later A.O.U. (1983), however, suggested that Arctic Loons may breed in remote areas of northwestern British Columbia.

Within the past decade Arctic Loons have been found breeding throughout wetlands in the boreal forest regions (Rowe 1959) of northern British Columbia.

That southward extension may influence populations of other waterbirds such as loons (*Gavia immer* and *G. stellata* — see Davis 1972) and grebes (*Podiceps grisegena* and *P. auritus*) through competition for food and breeding resources. This paper summarizes information on the occurrence and status, as well as nesting ecology, of the Arctic Loon in British Columbia for the period 1924 through 1983.

Methods

Records of occurrences and breeding of Arctic Loons for British Columbia were gathered from files in the Vertebrate Zoology Division in the British Columbia Provincial Museum. These included literature, (Campbell et al. 1979), breeding records in the British Columbia Nest Records Scheme (Myres et al. 1957), naturalists' observations, and the photo-records file (Campbell and Stirling 1971).

All records are from the spring and summer period, May through August, and came from all areas of British Columbia east of the Coast Mountains. Non-breeding occurrences include both spring transients and summer visitants. Breeding records are generally from mid-June through mid-August (Bailey 1948; Gabrielson and Lincoln 1959; Davis 1972).

Results and Discussion

Ninety-seven records of Arctic Loons are summarized (Table 1) for 1924-1983. Those include 16 breeding records for 12 different locations in the province (Figure 1; Table 2). These sites range in altitude from 500-760 m. Nearly 70 percent of all records are from the forested wetland regions north of latitude 59° North.

Distribution and Status

Arctic Loons have been recorded, in spring and summer, from 3 May to 28 August in various parts of interior British Columbia. South of latitude 54° North (i.e. Mt. Robson, Cariboo, southwest interior and Okanagan) the species is only a casual transient (11 records in 60 years from 3 May to 30 June). Further north it is apparently a summer resident,

TABLE 1. Spring and summer occurrences of the Arctic Loon in interior British Columbia, 1924–1983

Geographical Region	Locality and Number[1]	Dates	Reference
1. [2]Haines Triangle	59°31′N, 137°45′W — 1 record	5 June 1983	BCPM[3]
2. Atlin Lake	*Unnamed lake north Atlin*(3); *Davie Hall Lake*(2); *Grassy Lake*(3); Atlin Lake (2) — 8 records	9 June–3 August (1924–1981	Swarth 1930; BCPM
3. Liard River	*59°55′N, 129°13′W(3);* 59°58′N, 129°02′W(1); 59°57′N, 129°25′W(2); *59°42′N, 129°20′W(3);* 59°59′N, 128°58′W(2); Leo Lake(1); 59°55′N, 128°43′S(2); *near Iron Creek(1);* 59°48′N, 128°16′W(1); 59°48′N, 128°10′W(1); 59°49′N, 128°10′W(2); Nancy Lake(3); 59°46′N, 128°05′W(4); 59°47′N, 128°05′W; 2 km E McNab Lake(4); *S Iron Creek(2);* 59°47′N, 127°59′W(2); *59°46′N, 128°56′W(4);* 59°45′N, 127°55′W(2); 59°47′N, 127°48′W(1); *59°45′N, 127°40′W(3); 59°45′N, 127°34′W(3);* 18 km ESE McNab Lake(1); *Oregon Lake(2);* 59°44′N, 127°15′W(4); *59°43′N, 127°12′W(3);* 59°40′N, 127°07′W(2); 59°41′N, 127°04′W(1); *59°33′N, 126°26′W(4);* near Tatsino Creek(6); 59°25′N, 125°40′W(2); Nordquist Lake(2); 59°25′N, 125°40′W(2); W Aline Lake(6); *59°23′N, 125°32′W(2)* — 86 records	14 May–12 August (1977–1982)	BCPM; I. Robertson (personal communication)
4. Fort Nelson	Parker Lake(2); Summit Lake(1) — 3 records	13 May–5 July (1978–1979)	BCPM; Griffith 1973
5. Stikine River	Kinaskan Lake(1); Natadezlin Lake(2); Klahowya Lake(1); Happy Lake(1) — 4 records	22 July–27 August (1975–1979)	R. Garswell (personal communication); BCPM
6. Kitsault	*55°27′N, 129°20′W(2); 55°27′N, 129°21′W(2)* — 4 records	17 June–28 August (1980)	BCPM
7. Central Interior	Tetana Lake(2); Ross Lake(1); Babine Lake(3) — 6 records	27 May–11 August (1938–1983)	Stanwell-Fletcher and Stanwell-Fletcher 1943; BCPM
8. Peace River	Charlie Lake(1); near Chetwynd(1); near Dawson Creek(1); Swan Lake(2) — 4 records	21 June–21 August (1938–1978)	Cowan 1939; BCPM
9. Cariboo	Stum Lake(1); Williams Lake(1) — 2 records	8–15 June (1973–1978)	G. R. Ryder (personal communication); BCPM
10. Mt. Robson	Moose Lake(2) — 2 records	10–12 June (1974)	BCPM; Shepard 1975
11. Southwest Interior	Botanie Lake(2); Lightning Lake(1) — 2 records	2–30 June (1968–1973)	Rogers 1973; BCPM Rogers 1973; BCPM
12. Okanagan	Shuswap Lake(1); Swan Lake(1); Okanagan Lake(1); Osoyoos Lake(1) — 4 records	3 May–12 June (1942–1968)	T. Stevens (personal communication); Cowan 1947; BCPM

[1]Numbers in brackets indicate total number of loons observed; underlined localities indicate breeding.
[2]Numbers correspond to Figure 1.
[3]Includes wildlife observation and nest record cards in the British Columbia Provincial Museum collections.

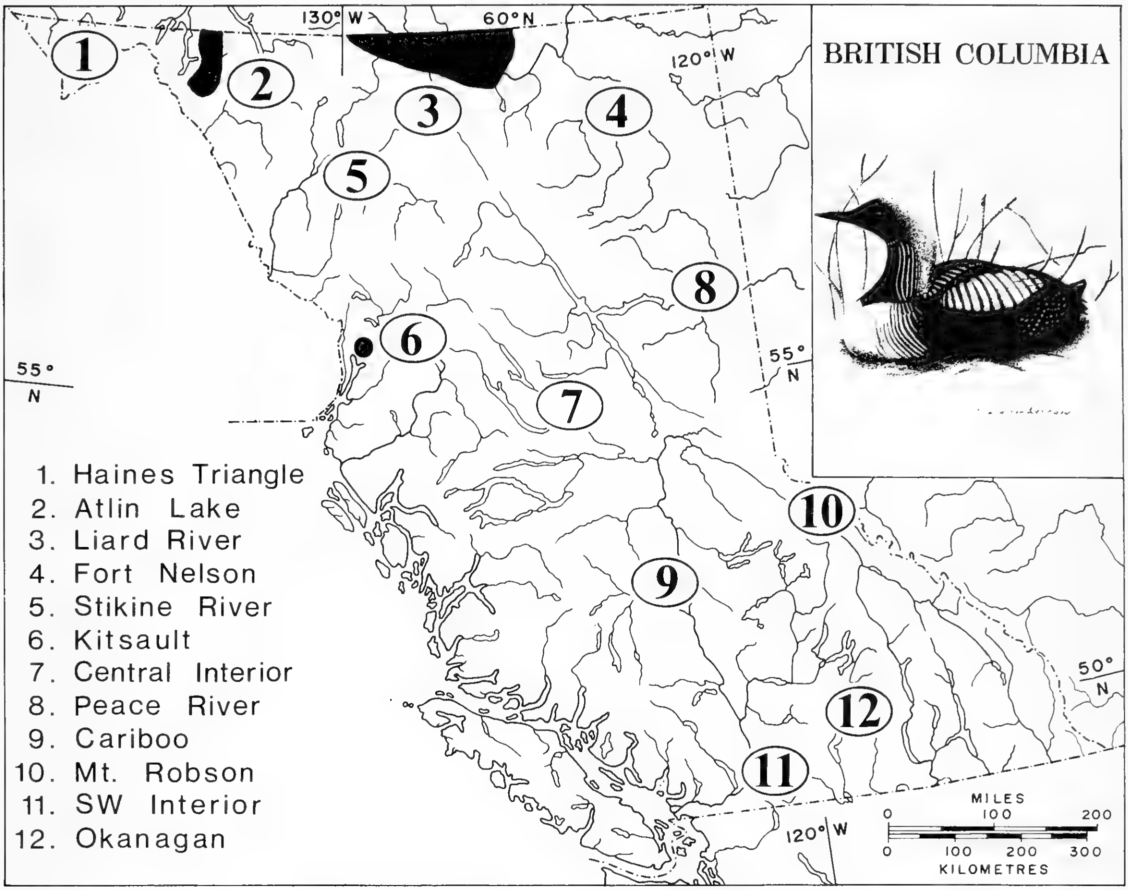

FIGURE 1. Geographical location of summer records of Arctic Loons in interior British Columbia, 1924–1983. Darkened areas depict breeding range.

arriving as early as 13 May and remaining through August. It is uncommon except in the vicinity of Atlin Lake, Liard River and Kitsault where breeding populations are established (Figure 1). For example, I. Robertson (personal communication) surveyed 123 different wetlands along a proposed gas pipelines corridor from Lower Post to Fort St. John (715 km) and found Arctic Loons on 31 (25%) of them. Of those six percent supported breeding pairs.

Arctic Loons may have nested in British Columbia earlier, in the late 1800's and early 1900's. MacFarlane and Charles (1908) reported nesting at Stuart Lake (Central Interior in Figure 1) on 29 May 1889, and Anderson (1915) found a pair breeding near Atlin on 15 June 1914. However, Brooks and Swarth (1925) and later Munro and Cowan (1947) considered the evidence inconclusive, the former claiming that those locations were too far south for this arctic species to breed. More recently Stanwell-Fletcher and Stanwell-Fletcher (1943) considered the Arctic Loon as a "probable breeder" on Tetana Lake in the central interior of the province.

In the summer of 1978 Provincial Museum staff confirmed breeding when they located two pairs of Arctic Loons, each with a small young, on small lakes south of the British Columbia/Yukon border. The following year a nest with an egg was found near Atlin (Figure 2). There are 16 known breeding locations in the province through 1983.

Arctic Loons have a disjunct breeding distribution in British Columbia (Figure 1). At least three pairs have nested on small lakes along the east side of Atlin Lake. Another much larger breeding population occupies the numerous wetlands paralleling the Liard River about 260 km east of Atlin Lake. The breeding range there extends about 260 km between longitudes

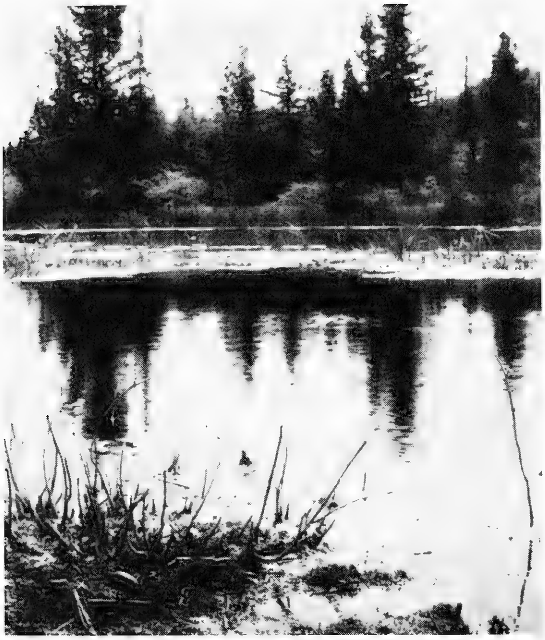

FIGURE 2. Arctic Loon nest with one egg, Davie Hall Lake north of Atlin, British Columbia, 2 July 1980. Nest site on drying island (see Petersen 1979).

129°25′W and 125°32′W and southward 80 km from the Yukon/British Columbia boundary to latitude 59°23′N. The only other known breeding area suggests a southern extension of nearly 450 km. In the vicinity of Kitsault (east of Alice Arm), two pairs have been found nesting on small subalpine lakes.

Nesting Ecology

Arctic Loons have been observed as early as 13 May (1979) at Parker Lake and 14 May (1981) near Liard River, in British Columbia. Peak arrival probably occurs during the third week of May, judging from arrival dates for Yukon (Salter et al. 1980) and Alaska (Bergman and Derksen 1977; Petersen 1979).

Arctic Loons breed on ponds and small lakes. In British Columbia these averaged 6.0 ha (range 3.6–41.4 ha, N = 16) in area, larger than in Alaska (1.8 ha — Petersen 1979; 3.0 ha —Bergman and Derksen 1977) and the Northwest Territories (2.8 ha — Davis 1972). In Scotland, however, lochs in excess of 30 ha are preferred (Bunday 1979). Breeding habitats near Kitsault and Atlin were larger (Table 3) than those near the Liard River.

In British Columbia, most nests (Table 3) were along shores, with others on islands, drying islands (see Figure 2) and beaver lodges. Petersen (1979) reports similar results for Arctic Loons nesting in the Yukon-Kushokwim River Delta, Alaska. Generally,

TABLE 2. Breeding records of the Arctic Loon in British Columbia[1]

Location	Elevation (m)	Date	Remarks	Reference
3. [2]59°55′N, 129°13′W	686	12 July 1978	2 Adults and 1 small young	R. W. Campbell
3. 59°42′N, 129°20′W	670	12 July 1978	2 Adults and 1 small young	R. W. Campbell
2. Davie Hall Lake	730	2 July 1980	Nest with 1 egg	B. M. Van Der Raay
2. Unnamed lake NW of Atlin	730	3 August 1980	2 Adults with 1 young	D. Fredricks, personal communication
3. South of Iron Creek	550	1 June 1980	Nest with 1 egg	D. J. Haddow, personal communication
3. Near Iron Creek	550	2 June 1980	Adult of nest	D. J. Haddow, personal communication
3. Oregon Lake	560	26 July 1980	Nest with broken eggs	R. W. Campbell
6. Kitsault Area	560	17 June 1980	Nest with 2 eggs	M. J. Chutter, personal communication
6. Kitsault Area	560	18 June 1980	Empty nest	M. J. Chutter, personal communication
2. Grassy Lake	732	7 June 1981	Nest with 2 eggs	B. J. Petrar
3. 59°45′N, 127°34′W	690	24 June 1981	2 Adults and 1 young	I. Robertson
3. 59°43′N, 127°12′W	760	24 June 1981	1 Adult and 2 young	I. Robertson
3. 59°46′N, 128°56′W	750	16 July 1981	2 Adults and 2 young	I. Robertson
3. 59°33′N, 126°26′W	500	16 July 1981	2 Adults and 2 young	I. Robertson
3. 59°23′N, 125°32′W	540	17 July 1981	2 Adults and 1 young	I. Robertson
3. 59°45′N, 127°40′W	750	12 August 1981	2 Adults and 1 young	I. Robertson

[1]Extracted from the British Columbia Nest Records Scheme.
[2]Numbers correspond to geographical regions in Figure 1.

TABLE 3. Characteristics of Arctic Loon nesting sites in British Columbia

	Atlin N = 3	Liard River N = 11	Kitsault N = 2
Nest Location[1]			
Island	1	0	2
Drying Island	2	0	0
Shore	0	2(8)[2]	0
Beaver Lodge	0	1	0
Wetland surface area (hectares)	15.1 (7–21.8)[3]	7.3 (3.6–19.6)	33.2 (24.9–41.4)

[1]Modified from Petersen (1979).
[2]Number in brackets assumed for broods due to lack of islands in wetlands.
[3]Mean and range for surface area of wetlands.

if islands are available they are preferred as nest sites (see Lehtonen 1970; Davis 1972; Bergman and Derksen 1977; Bundy 1979). For example near Atlin and Kitsault all nest-sites were on islands (Table 3) whereas other nearby wetlands, lacking islands, were unoccupied. In wetlands along the Liard River islands are generally absent, hence the use of shores as nest sites.

Clutches in four of five nests found with eggs (Table 2) contained two eggs, the usual clutch-size for Arctic Loons (Davis 1972). In British Columbia eggs have been found in nests from 1 June through 2 July and young seen from 24 June through August (Table 2). The calculated egg-laying period, using 29 days as the incubation period (see Palmer 1962), would extend from at least 25 May through early June, and the peak hatching period would extend most years from late June through early July. We have no information on hatching success. Although six of the nine broods observed contained a single young, Davis (1972) indicated that adults rarely raise more than a single young.

The Arctic Loon has been confirmed as a breeding species in northern British Columbia within the past decade. The breeding range of the Common Loon (Godfrey 1966) overlaps with that of Arctic Loons, but the former species utilizes much larger lakes for nesting. However, if Arctic Loons expand their breeding range in the province, competition for nesting and feeding requirements with other loon species will become evident. Perhaps this may occur in the vicinity of Haines Triangle where Common Loons and Red-throated Loons already co-exist.

Acknowledgments

We extend our thanks to the following naturalists who contributed observations to various files at the British Columbia Provincial Museum: G. Anweiler, F. Benton, D. A. Blood, G. Campbell, R. W. Campbell, T. Carson, M. Chutter, M. J. Comfort, B. S. Ford, E. Foster, J. B. Foster, R. Fox, D. Fredricks, H. M. Garrioch, W. Gorman, L. Goulet, G. Groves, F. Guillon, D. J. Haddow, P. Henderson, D. Innes, M. Innes, R. E. Luscher, M. McNall, M. K. McNicholl, K. P. Morrison, D. Parker, B. J. Petrar, J. Pojar, I. Robertson, G. R. Ryder, T. Stevens, D. Stirling, D. Thompson and B. M. Van Der Raay.

The drawing of the Arctic Loon in Figure 1 was done by B. M. Van Der Raay. E. Bates typed the manuscript. T. E. Reimchen and A. J. Erskine provided helpful comments on the manuscript.

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Received 20 January 1984
Accepted 23 November 1984

Abondance et activités du Pigeon biset, *Columba livia*, dans le port de Montréal, Québec

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Lévesque, Hélène, et Raymond McNeil. 1985. Abondance et activités du Pigeon biset, *Columba livia*, dans le port de Montréal, Québec. Canadian Field-Naturalist 99(3): 343–355.

Une étude du Pigeon biset (*Columba livia*) a été réalisée dans la section Vieux Port du port de Montréal de mai 1981 à mars 1982. Le territoire étudié, qui sert essentiellement au transport du grain, se caractérise par la présence de deux silos et des équipements associés (galeries, tours marines, réseau routier et de chemins de fer); il est limité d'un côté par une autoroute surélevée. Le nombre de Pigeons bisets peut excéder 2000 individus; il varie selon les saisons et les périodes de la journée. Les activités des pigeons sont reliées aux caractéristiques physiques des lieux. La majorité des pigeons observés sont perchés. Beaucoup d'entre eux s'alimentent dans le port mais ils y sont souvent dérangés, surtout durant les heures de travail, par les activités de manutention et de déchargement des céréales. En été, les pigeons peuvent se concentrer au sol en des aires de repos mais ce phénomène est plus rare en hiver. Des nids actifs ont été vus durant toute l'année. À l'approche de l'hiver, le nombre de pigeons augmente a certains sites et diminue à d'autres; cette redistribution dépendrait surtout de la couverture de neige qui limite l'accès aux céréales répandues au sol.

Mots clés: Pigeon biset, *Columba livia*, abondance, activités, port de Montréal, Québec.

A study of the Rock Dove (*Columba livia*) was conducted in the old section of the Port of Montréal from May 1981 to March 1982. The study area served mainly for grain transport and was characterized by the presence of two elevators and related constructions (galleries, marine towers, road and railway network), and was bordered on one side by an elevated expressway. The number of pigeons may exceed 2000 individuals; it varied depending on seasons and periods of the day. Pigeon activities were correlated with local features. Pigeons were generally seen perched. Most of them fed around the harbour but they were often disturbed, especially during working hours, by human activities related to the handling and unloading of grain. In summer, pigeons gathered on the ground in resting areas but such a phenomenon was less common during the winter. Active nests were found throughout the year. From summer to winter, pigeon numbers increased at some sites and decreased at others; this redistribution of individuals largely depended on the snow cover which limited access to grain spilled on the ground.

Key Words: Rock Dove, *Columba livia*, abundance, activities, Montréal harbour, Québec.

Depuis des temps très reculés, le Pigeon biset (*Columba livia*) profite d'une certaine association avec l'homme ainsi que des modifications apportées par ce dernier au milieu naturel (déboisement, constructions verticales, etc.) (Woldow 1972) pour étendre son aire de répartition originale. Aujourd'hui c'est un oiseau que l'on retrouve partout dans les régions urbanisées et agricoles du monde entier (Goodwin 1977; Murton 1971; Long 1981).

Dans les zones urbaines, les pigeons se rencontrent en groupes de dimensions variées. Ils nichent et se reposent sur les corniches d'édifices de toutes sortes et s'alimentent dans les parcs, les places publiques, les gares de triage, les ports céréaliers, etc. (Goodwin 1954; Thearle 1968; Murton 1971). Leur présence dans les villes donne lieu à des réactions contradictoires. Habituellement, les badauds les apprécient (Goodwin 1954; Heusmann 1975), tandis que les autorités municipales, portuaires et autres ont plutôt tendance à s'inquiéter de leur présence pour des raisons de salubrité et d'économie (Thearle 1968; Murton 1971; Long 1981). Pour ces raisons, des opérations de contrôle sont quelquefois tentées dans le but de contenir ou de diminuer leurs effectifs (Ridpath et al. 1961; Thearle 1968; Murton et al. 1972a; Conseil de Paris[1]). Le Pigeon biset a été introduit au Canada en tant qu'oiseau de ferme dès les premiers temps de la colonie (Saunders 1935); il est une espèce dominante presque partout dans les grandes villes canadiennes (Erskine 1980). À Montréal, les pigeons ont probablement pour ancêtres des individus échappés des fermes locales (Ouellet 1974). Les administrateurs du port de Montréal où l'on effectue la manipulation commerciale de grandes quantités de céréales se préoccupent de l'insalubrité causée par les fientes des

[1]Lettre en date du 18 mars 1975 de M. le Préfet de Paris suite à la délibération du 27 juin 1974 relative à la proposition 1974, C. 132 concernant les mesures pour lutter contre la prolifération des pigeons à Paris. Imprimé municipal, Hôtel de Ville, Paris.

pigeons ainsi que des risques de contamination encourus, le pigeon étant vecteur de maladies transmissibles à l'homme ou aux animaux domestiques (Lépine et Sautter 1951; Littman et Schneirson 1959; Rehacek et Brezina 1976). Jusqu'à maintenant, la seule étude consacrée à une population de pigeons occupant une zone portuaire est celle de Murton et al. (1972a, 1972b, 1973) et elle concerne le port de Manchester (Angleterre). Récemment, Lefebvre et Giraldeau (1984) ont étudié la fréquentation quotidienne par le Pigeon biset de sites situés au centre-ville de Montréal, mais aucun de leurs sites n'était situé dans la zone portuaire. Dans le but de juger de la pertinence de limiter ou de contrôler leurs effectifs, la présente étude a pour objectif de décrire l'abondance et les activités du Pigeon biset dans le port de Montréal, plus particulièrement dans le secteur du "Vieux Port" et ses alentours, en tenant compte notamment des variations saisonnières dans un climat aux étés chauds et aux hivers rigoureux.

Aire d'étude

La ville de Montréal (45° 28′ N, 73° 45′ O) est caractérisée par un climat continental comportant des étés chauds (température moyenne de 21° C en juillet) et des hivers froids (température moyenne de -10° C en janvier); il y tombe en moyenne 230 cm de neige entre novembre et avril et, de décembre à mars, la couche moyenne de neige au sol ex- `de 1 cm (Environnement Canada, données inédites).

Le port de Montréal occupe un large territoire constitué entre autres d'une grande partie de la rive-ouest du fleuve Saint-Laurent au sud-est de l'île de Montréal. Deux secteurs servent en prédominance au transport des céréales, même si cette activité occupe aujourd'hui une place moins importante qu'au début du siècle (Brouillette 1967). Le plus ancien (le "Vieux Port") qui constitue l'aire de la présente étude s'étend à l'est de la rue de la Commune, de l'autoroute Bonaventure au sud jusqu'à la rue Berri vers le nord (Figure 1).

Quatre silos assurent l'entreposage du grain manutentionné au port de Montréal. Le secteur du Vieux Port en comporte deux (numéros 1 et 5; Figure 1), qui comptaient en 1981–82 pour un peu moins de la moitié de la capacité totale de l'ensemble des silos du port. En

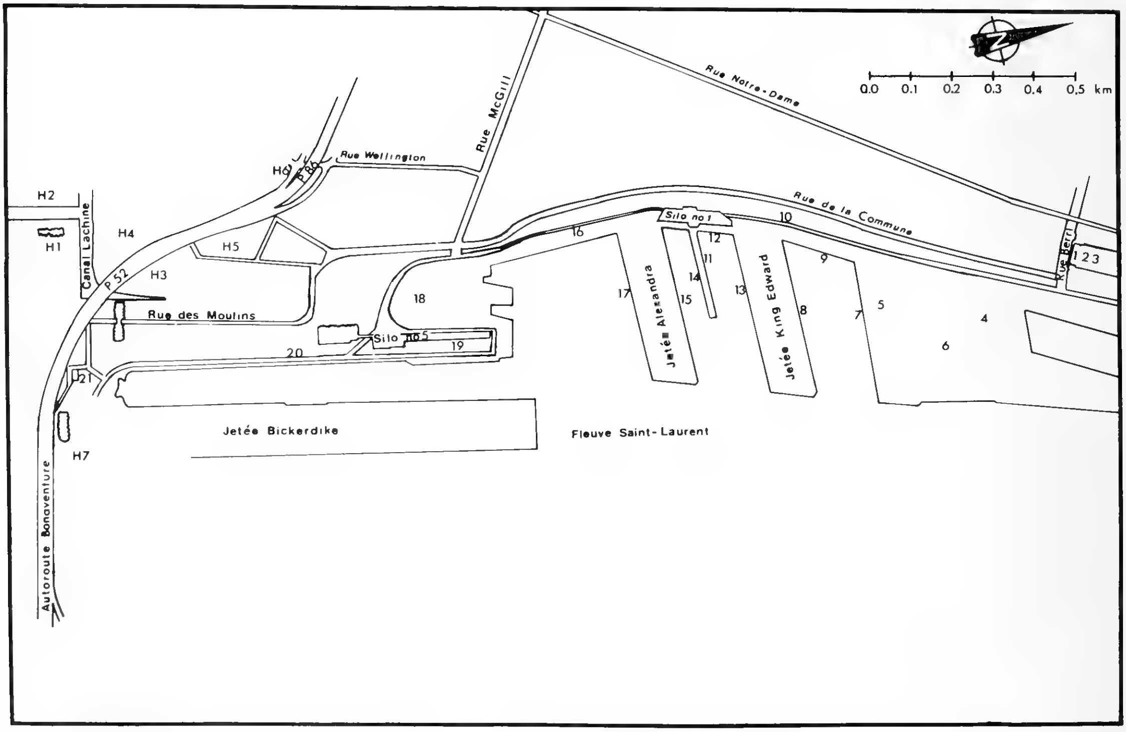

FIGURE 1. Aire d'étude: les numéros 1 à 21 correspondent aux sites d'observation dans le secteur du Vieux Port; P1 à P86 représentent l'emplacement des piliers de l'autoroute Bonaventure; H1 à H7 montrent l'emplacement d'édifices, parcs et terrains vagues.

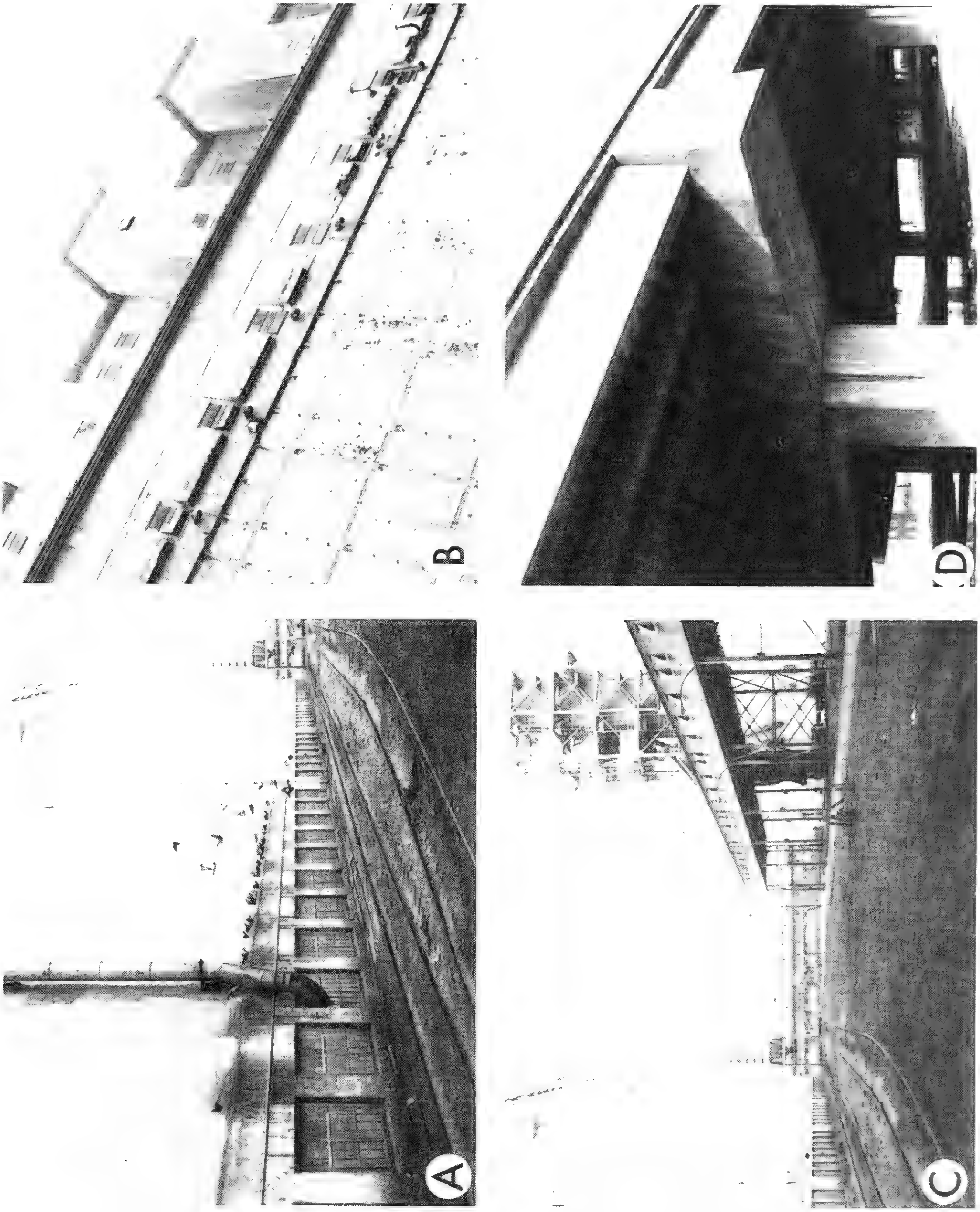

FIGURE 2. Structures architecturales occupées par les pigeons dans le port de Montréal et ses environs: (A) silo n° 5 (pigeons perchés près de la voie ferrée où se trouvent des grains épars); (B) silo n° 5 (fenêtres ouvertes); (C) silo n° 5 (galeries, tours marines et réseau routier); (D) piliers de l'autoroute Bonaventure.

plus des deux silos et des différentes structures de chargement qui les accompagnent (galeries, tours marines, etc.; Figure 2), le Vieux Port comporte une dizaine de hangars de transit, deux terrains vagues, ainsi qu'un réseau de chemins de fer et de routes qui longent les installations. En 1981, le quart des activités du port de Montréal (6,2 des 24,8 millions de tonnes de marchandises manutentionnées) était relié à l'industrie céréalière. La majorité des grains sont transportés par voie d'eau, le reste étant envoyé et reçu par camions et par trains. La manutention des céréales s'effectue de façon continue pendant toute l'année; elle est à son maximum au printemps et à l'automne alors qu'elle est ralentie en hiver, à cause de la fermeture de la voie maritime.

La partie sud du Vieux Port, à proximité du canal Lachine, est davantage une zone industrielle dominée par les installations de nombreuses compagnies agro-alimentaires (minoteries, distilleries, malteries, etc.) et comporte plusieurs parcs et terrains vagues. La voie surélevée de l'autoroute Bonaventure (Figure 1) est portée par plusieurs piliers sur lesquels des pigeons nichent à une hauteur de 6 à 10 m du sol (Figure 2D).

Méthodes

Les données concernant l'abondance des pigeons, leurs activités et les sites qu'ils fréquentent ont été recueillies lors des 108 parcours d'un trajet comptant 21 sites (numéros 1 à 21; Figure 1) d'observation (toits, corniches, terrains à découvert, etc.) dans le Vieux Port et 119 parcours d'un trajet permettant l'observation de 86 piliers de l'autoroute Bonaventure (Figure 2D) et des édifices, parcs et terrains vagues environnants (P1 à P86 et H1 à H7; Figure 1).

Durant la période d'été (du 27 mai au 1er septembre 1981), ces parcours ont été effectués plusieurs fois par semaine, les départs se situant à toutes les 2 heures de 06:00 à 18:00. Du 3 septembre au 31 décembre 1981, ils ont été espacés d'environ 15 jours et effectués à 10:00, 12:00, 14:00 et 16:00. Enfin, du 19 janvier au 19 mars 1982, ils ont été parcourus plus fréquemment et aux heures suivantes: 08:00, 10:00, 12:00 et 14:00. Les trajets de l'autoroute Bonaventure et du Vieux Port ont duré respectivement 60 et 90 minutes environ. Des visites sporadiques ont aussi été faites à l'intérieur du silo no 5 au cours de l'automne et de l'hiver.

Lors des trajets d'observation, selon une terminologie adaptée d'après Murton et al. (1972a), nous avons noté quelle quantité de pigeons s'alimentaient ou se trouvaient perchés, au nid, en repos au sol (ne s'alimentant pas, mais s'occupant à d'autres activités comme le bain, la parade nuptiale, etc.), ou en vol (en vol continu en formation; les individus qui volaient seuls ou à haute altitude ont été ignorés). Au moment des observations des piliers de l'autoroute Bonaventure et de leurs environs, lorsqu'inférieur à 5, le nombre de pigeons vus au sol était intégré au nombre total de pigeons perchés et au nid.

Après avoir regroupé en classes (cases) d'abondance, en fonction des périodes de la journée (ou d'intervalles de dates), les nombres globaux de pigeons vus lors de chaque trajet d'observation, nous les avons analysés en réalisant des tableaux de contingence selon la méthode décrite par Legendre et Legendre (1979). Ces tableaux comportent les probabilités conditionnelles (pourcentage de trajets dans une classe d'abondance à telle ou telle période) classifiées en fonction de périodes données et les probabilités inconditionnelles (probabilité des trajets de correspondre à cette classe d'abondance indépendemment de la période). Ces calculs ont été réalisés à l'aide des programmes Vernorm et Parti du logiciel R disponible au Centre de calcul de l'Université de Montréal. Les tableaux de contingence permettent de maximiser la probabilité du χ^2 de Wilks pour la non-homogénéité de la distribution dans le temps des nombres globaux de pigeons vus lors des trajets.

Les données météorologiques (°C, humidité relative) correspondant aux jours et heures des trajets ont été obtenues de la station météorologique du Service de l'Environnement atmosphérique d'Environnement Canada à Dorval. Lors de chaque trajet, nous avons pris note du degré d'ensoleillement ou de la couverture de nuages, des vents et des précipitations, ainsi que de toute manifestation d'activités humaines (e.g. va-et-vient intense de camions et de wagons, chargements de navire, etc.) susceptibles de déranger les pigeons.

Résultats et discussion

Abondance des pigeons

Lors de l'ensemble des recensements effectués sur le territoire à l'étude, 1143 ± 338 et 795 ± 224 pigeons ont été dénombrés en moyenne respectivement dans le secteur du Vieux Port et de l'autoroute Bonaventure (Tableau 1). Ne tenant compte que des données obtenues lors des trajets effectués au milieu du jour (12:00, 14:00 et 16:00; voir plus loin), on constate que les nombres moyens de pigeons vus dans le port de Montréal passent respectivement à 1290 ±333 et 715 ± 200 pour les secteurs du Vieux Port et de l'autoroute Bonaventure. Étant donné le fait que ces deux populations sont probablement limitées à leurs secteurs géographiques respectifs et pour ainsi dire ne se mélangent pas, exception faite des échanges entre les secteurs de l'autoroute Bonaventure et de la zone environnant le silo no 5 dans le Vieux Port (Lévesque 1983), cela donne une population globale de 2000 pigeons.

TABLEAU 1. Répartition, en fonction des heures de parcours, du nombre moyen de pigeons vus lors des trajets d'observation du Vieux Port et du secteur de l'autoroute Bonaventure

Heures	Secteur du Vieux Port: Nombres	Ecart-type	Nombre de cas	Secteur de l'autoroute Bonaventure: Nombres	Ecart-type	Nombre de cas
06:00	1050	± 154	11	938	± 127	10
08:00	891	± 188	17	854	± 242	23
10:00	1132	± 354	25	806	± 237	27
12:00	1253	± 276	18	732	± 195	19
14:00	1293	± 393	22	655	± 214	23
16:00	1392	± 290	9	821	± 132	10
18:00	744	± 101	4	1020	± 98	5
Moyennes: 12:00, 14:00, 16:00	1290	± 333	49	715	± 200	52
Globale	1143	± 338	106	795	± 224	117

Cette estimation, quelque 2000 individus, pour les pigeons du Vieux Port de Montréal ne représente évidemment que les pigeons visibles à l'observateur lorsqu'il parcourt les trajets comprenant plusieurs postes d'observation stratégiques. Dissimulés à l'intérieur des hangars, silos et autres bâtiments vétustes ou sur les toits et corniches de divers bâtiments ou les piliers de l'autoroute Bonaventure, un nombre indéterminé de pigeons demeurent invisibles. D'octobre 1981 à mars 1982, en moyenne 114 ± 37 pigeons ont été vus à l'intérieur du silo n° 5. Compte tenu de cela, puis du nombre moyen de pigeons recensés en hiver aux sites n^{os} 18, 19 et 20 (Figure 1), on peut estimer à environ 500 individus le nombre de pigeons du secteur du silo n° 5. De là, les pigeons dissimulés à l'intérieur du silo n° 5 compteraient pour à peu près 23% de la population globale du secteur. On ne peut dire si un tel pourcentage est applicable à l'ensemble des sites ou groupes de sites du Vieux Port. Cependant, au port de Manchester, Murton et al. (1972a) estiment à 9–11% (maximum exceptionnel de 21%) de la population globale les pigeons dissimulés dans des bâtiments et non visibles lors d'itinéraires d'observation.

Variation selon les heures du jour

Les décomptes de pigeons au port de Montréal ont été répétés plusieurs fois par jour de 06:00 à 18:00 (Tableau 1). Globalement, la répartition du nombre moyen de pigeons observés affiche une distribution horaire bimodale. Un horaire quotidien bimodal d'utilisation des sites d'alimentation a d'ailleurs été constaté par Lefebvre et Giraldeau (1984) dans le centre-ville de Montréal. On constate cependant dans le Vieux Port (χ^2 de Pearson = 19,696, dl = 1, $p < 0,05$), tout comme à Manchester (Murton et al. 1972a), que les pigeons sont vus en plus grands nombres l'après-midi (lorsqu'ils quittent leur nid ou leur gîte pour s'alimenter), soit lors des trajets débutant entre 12:00 et 16:00.

Cette tendance peut être confirmée grâce au tableau de contingence (Tableau 2) où sont regroupés en classes d'abondance (cases), en fonction des périodes de la journée, les nombres globaux de pigeons vus lors de chaque trajet d'observation. Au cours de la période de 10:00 à 16:00 on obtient significativement moins de nombres globaux faibles (< 965 pigeons) et plus de nombres globaux élevés (> 965) que lors des trajets débutants à 06:00, 08:00 et 18:00. Dans le Vieux Port, cachés dans les édifices ou silos, les pigeons paraissent moins nombreux le matin. Dans le secteur de l'autoroute Bonaventure cependant, les petits nombres totaux (< 925) sont plus fréquents l'après-midi de 12:00 à 16:00 (χ^2 = 14,715, dl = 1, $p < 0,05$). La différence entre les deux secteurs est d'ailleurs montrée par la hauteur relative des colonnes claires (lignes parallèles inclinées) et obscures de la figure 3. Elle est liée au fait que dans le secteur de l'autoroute Bonaventure, lors des trajets d'observation, on énumère une plus grande proportion de pigeons au nid et au repos; comme on le verra plus loin, un certain nombre d'individus quittent l'autoroute au milieu de la journée (Lévesque 1983) pour des lieux d'alimentation ailleurs (e.g. zone du silo n° 5 dans le secteur du Vieux Port).

Variations saisonnières

La figure 3 illustre les variations mensuelles du nombre moyen de pigeons vus lors des trajets d'observation dans les secteurs du Vieux Port et de l'autoroute Bonaventure. Dans le secteur du Vieux Port, on observe une augmentation en automne (octobre, novembre et décembre) tandis qu'à l'autoroute Bonaventure, le nombre de pigeons diminue progressivement à partir de juin, avec un minimum en janvier.

Cette diminution progressive du nombre de pigeons dans le secteur de l'autoroute Bonaventure (Figure 3)

TABLEAU 2. Probabilités conditionnelles et inconditionnelles, en fonction des périodes de la journée, des classes d'abondance de pigeons vus lors des trajets d'observation ainsi que de la cardinalité des cases

	Classes d'abondance des pigeons observés			
	Secteur du Vieux Port		Secteur de l'autoroute Bonaventure	
Périodes de la journée	597–965	966–2080	0–925	> 926
06:00, 08:00, 18:00	22[1] (0,688)[2]** Vt = 2,4254	10 (0,313) Vt = 3,3625*		
10:00, 12:00, 14:00, 16:00	17 (0,233) Vt = 2,6796*	56 (0,767)** Vt = 1,9785		
06:00, 08:00, 10:00, 18:00			33 (0,508) Vt = 2,0093	32 (0,492)** VT = 2,0284
12:00, 14:00, 16:00			44 (0,846)** Vt = 1,8666	8 (0,154) Vt = 3,5824
Cardinalité globale	39	66	77	40
Probabilité inconditionnelle	0,3714	0,6286	0,6581	0,3419

*Vt: la valeur test (Legendre et Legendre 1979) est significative à $p < 0,05$
**La probabilité conditionnelle dépasse la probabilité inconditionnelle
[1]Cardinalité de la case
[2]Les parenthèses indiquent la probabilité conditionnelle

à l'approche de la saison froide est confirmée par le tableau de contingence (Tableau 3) où sont regroupés en classes d'abondance, en fonction d'intervalles de dates, les nombres totaux de pigeons lors de chaque trajet d'observation. Ce tableau montre que du 27 mai au 15 octobre en obtient significativement plus de nombres totaux élevés (> 636; $p < 0,05$) et moins de nombres totaux faibles (< 635) alors que c'est l'inverse du 16 octobre au 19 mars.

L'augmentation marquée du nombre total de pigeons recensés dans le secteur du Vieux Port (Figure 3), vraisemblablement en provenance, entre autres, du secteur de l'autoroute Bonaventure (Lévesque 1983), coïncide avec le moment où les pigeons sont normalement dans la période réfractaire de leur cycle de reproduction (Hakkinen et al. 1973; Murton et al. 1973). Il serait logique de penser que durant l'automne les pigeons du port et des rues avoisinantes (Vieux Montréal) se regroupent à proximité d'aires d'alimentation principales tandis qu'en période de reproduction, ils se dispersent dans les divers sites de nidification disponibles (en particulier l'autoroute Bonaventure). Cette idée de concentration durant la période réfractaire est en accord avec la théorie énoncée par Emlen (1952) qui fait un lien entre la diminution de l'activité des hormones sexuelles, la diminution de la tendance à la dispersion et l'augmentation de la tendance au grégarisme.

Effets des conditions météorologiques

Il est difficile d'établir un lien entre les conditions météorologiques (° C, humidité relative, degré d'ensoleillement, couverture de nuages, vents et précipitations) et les nombres de pigeons vus dans les secteurs du Vieux Port et de l'autoroute Bonaventure. Dans le secteur du Vieux Port, une corrélation négative significative (coefficient de Kendall selon Nie et al. 1975) est obtenue uniquement en fonction de l'ensoleillement (τ = -0,2069, p = 0,007). Il semble qu'en été (84 des 108 trajets dans le secteur du Vieux Port), au cours des jours ensoleillés, les pigeons se perchent à l'ombre en des endroits moins exposés, et ils seraient de ce fait plus difficiles à déceler lors des décomptes. Ceci pourrait expliquer la tendance à dénombrer moins de pigeons lors des jours ensoleillés que lors des jours nuageux ou partiellement ennuagés. Cette relation ne se vérifie pas à l'autoroute Bonaventure parce que là les pigeons y sont presque toujours vus à l'ombre sur les piliers.

La diminution marquée dans le nombre de pigeons observés dans le secteur du Vieux Port à compter de janvier (Figure 3) ainsi que le creux constaté à la même période dans le secteur de l'autoroute Bonaventure peuvent s'expliquer en partie par une augmentation du taux de mortalité suite aux grands froids. De fait, les lendemains de nuits très froides (-30° C), nous avons trouvé une quarantaine de pigeons morts (jusqu'à 10 individus sous un même pilier) dans le secteur de l'autoroute Bonaventure. Des cas semblables de pigeons trouvés morts ont été rapportés par des employés des Ports nationaux dans le secteur du Vieux Port. De là, on peut penser qu'en dépit de ressources alimentaires disponibles (voir plus loin), certains oiseaux, souvent dérangés par les activités reliées au transbordement des grains, etc. (Murton et al. 1972b), se trouvent incapables d'accumuler suffi-

TABLEAU 3. Probabilités conditionnelles et inconditionnelles, en fonction d'intervalles de dates, des classes d'abondance de pigeons vus lors des trajets d'observation dans le secteur de l'autoroute Bonaventure ainsi que de la cardinalité des cases

	Classes d'abondance des pigeons observés	
Intervalles temporelles	0–635	636 et +
du 27 mai au 15 octobre	2[1] (0,026)[2] —	76 (0,974)** Vt = 3,3581*
du 16 octobre au 19 mars	27 (0,692)** Vt = 3,8027*	12 (0,308) Vt = 5,2809*
Cardinalité globale	29	88
Probabilité inconditionelle	(0,2479)	(0,7521)

*Vt: la valeur-test (Legendre et Legendre 1979) est significative à $p < 0,05$

**La probabilité conditionnelle dépasse la probabilité inconditionnelle

[1]Cardinalité de la case

[2]Les parenthèses indiquent la probabilité conditionnelle

samment de ressources calorifiques pour faire face à de tels froids. La diminution constatée dans le nombre de pigeons vus en janvier pourrait théoriquement s'expliquer par un déplacement temporaire d'une partie de la population vers d'autres secteurs. Ce phénomène, s'il existe, nous paraît d'une importance secondaire compte tenu du fait que la répartition d'oiseaux marqués nous montre que les pigeons sont très sédentaires, surtout en hiver, dans les secteurs du Vieux Port et de l'autoroute Bonaventure (Lévesque 1983). De fait, au cours de la saison froide où moins de pigeons se reproduisent (Erskine 1976; Kakkinen et al. 1973; Dunmore et David 1963), on doit davantage s'attendre à ce que ces secteurs qui comportent des abris et des ressources alimentaires attirent les pigeons moins favorisés d'autres secteurs de l'île de Montréal.

Activités des pigeons

Les pigeons sont surtout vus perchés ou au repos (près de 80% dans le secteur du Vieux Port; voir tableau 4), au nid ou au dortoir (secteur de l'autoroute Bonaventure; voir tableau 5).

1) Secteur du Vieux Port

La figure 4B répartit en pourcentage les pigeons vus à chaque site en fonction des catégories d'activité. On retrouve des pigeons perchés dans tous les sites mais dans des proportons très diverses; ils dominent (plus de 50%) partout sauf aux sites n^{os} 6, 14, 16 et 18. Des pigeons au repos ou qui s'alimentent sont vus dans 20 des 21 sites. Des pigeons au nid ou en volées sont vus seulement à certains sites. L'utilisation des sites par le pigeon est évidemment fortement dépendante de leurs caractéristiques physiques. Chacun de ces sites comporte normalement des bâtiments dont les corniches servent de perchoir (et parfois de gite ou site de nidification) aux pigeons, associés à du grain épars ou des amas de grains sur un quai ou une portion de route.

Le nombre total moyen de pigeons observés a varié énormément d'un site à l'autre (Figure 4A; voir aussi la figure 1 pour l'emplacement des sites). On retrouve en moyenne 4,4 à 213,3 pigeons par site. C'est aux sites où ils peuvent s'alimenter (sites n^{os} 6, 7, 10 et 19) ou à proximité de ceux-ci (sites n^{os} 18, 20 et 9) que les pigeons sont plus abondants. L'attrait du silo n° 5 (représenté par le site n° 19) ainsi que des sites n^{os} 7 (endroit important de chargement du grain) et 10 vient de l'abondance de nourriture qu'on y retrouve au sol. Les pigeons perchés aux sites n^{os} 9, 18 et 20 surplombent l'une ou l'autre de ces aires d'alimentation (amas de grain), c'est pourquoi ils y sont nombreux.

Malgré le fait que le secteur du Vieux Port comporte des sources d'alimentation attrayante, la majorité des pigeons (60,4% du nombre total moyen des individus du 27 mai 1981 au 16 mars 1982) utilisent ce secteur surtout pour se percher (Tableau 4) et l'alimentation (19,5%) vient au deuxième rang.

Ces faits peuvent sembler paradoxaux à première vue si on néglige l'importance des dérangements humains. En effet, l'activité humaine souvent intense qui se déroule dans le port empêche les pigeons d'avoir accès aux amas de grain gaspillé. Les oiseaux ne peuvent s'en alimenter que lorsque l'activité ralentit. Murton et al. (1972b) ont étudié le comportement de deux groupes de pigeons qui s'alimentaient au port de Manchester et ont remarqué que ceux-ci pouvaient attendre plusieurs heures sur un perchoir qui leur permettait de surveiller les amas de céréales avant de pouvoir enfin s'alimenter. Au Vieux Port, les pigeons que l'on voit perchés ne sont pas à leur dortoir; il semble qu'une bonne partie d'entre eux soient en train d'attendre une "accalmie" puisque plusieurs d'entre eux sont perchés tout près de tas de céréales en des sites fort peu abrités mais sûrement très avantageux quant à la proximité d'une source de nourriture. Il paraît évident que le rôle du secteur du Vieux Port comme site d'alimentation pour les pigeons est plus grand que ne le laisse voir la proportion moyenne de 19,5% d'oiseaux vus en train de s'alimenter.

Des visites effectuées à l'intérieur du silo n° 5 nous ont permis de constater la présence de nombreux emplacements de nids (actifs ou non) ainsi que des amas de céréales disposés un peu partout au hasard des fuites de grains. Aux sites d'alimentation extérieurs s'ajoutent donc plusieurs sources de nourriture disposées à l'intérieur de différents bâtiments. Cependant, la présence de travailleurs de 08:00 à 17:00 empêche les pigeons de les exploiter durant les heures

de la journée. Parallèlement, rappelons que dans le secteur du Vieux Port, les pigeons sont vus à l'extérieur en plus grands nombres lors des trajets qui débutent entre 10:00 et 16:00 (Tableau 1).

On ne trouve qu'une faible proportion (17,1%; voir tableau 4) de pigeons au repos au sol; ils sont plus abondants aux sites n^{os} 6, 14, 16 et 18 (Figure 4B) parce qu'il s'agit de vastes terrains à découvert où ils peuvent s'ébattre en toute tranquilité n'y étant que rarement dérangés par les activités du port.

La faible proportion de pigeons recensés au nid lors des trajets d'observation dans le secteur du Vieux Port (Figure 4B et Tableau 4) tient à deux facteurs. D'abord les distances auxquelles certaines observations doivent être faites empêchent de relever des preuves directes ou indirectes (Lees 1946) qui permettent de distinguer un pigeon au nid d'un pigeon simplement perché. Les sites n^{os} 1 et 2 font exception: ils comportent des supports très bien abrités pour les nids; il est possible de les observer à une très courte distance et, de ce fait, de les dénombrer. Ensuite, comme l'indiquent nos observations à l'intérieur du silo n° 5, la majorité des pigeons, selon leurs habitudes (Goodwin 1977; Gompertz 1957), préfèrent et réussissent à nicher à l'intérieur de différentes constructions vétustes dans le Vieux Port. À Manchester, la situation est similaire (Murton et al. 1973).

À plusieurs sites (Lévesque 1983), le nombre total moyen de pigeons vus avant le 16 octobre est significativement différent de celui obtenu après. D'été en hiver, le nombre total moyen augmente pour certains sites et diminue pour d'autres. Le nombre de pigeons observés au repos au sol en hiver compte pour seulement 3,0%, comparativement à 21,4% en été (Tableau 4); cela peut être relié à trois facteurs. D'abord, les besoins énergétiques plus grands face aux grands froids obligent les pigeons à consacrer plus de temps à l'alimentation ou plus exactement à l'alimentation et à l'attente des accalmies leur permettant de s'alimenter. En second lieu, la durée d'éclairement étant plus courte en hiver, le pigeon dispose de très peu de temps excédentaire une fois ces besoins vitaux satisfaits. Enfin, les sites de repos habituellement fréquentés en été sont, en hiver, recouverts de neige et de glace et il est fort probable que dans le cas où un pigeon chercherait un site de repos en hiver, il préférerait demeurer sur un perchoir bien exposé au soleil. De fait, la diminution du pourcentage de pigeons au sol correspond sensiblement à l'augmentation du pourcentage de pigeons perchés qui passe de 55,7 en été à 75,2 en hiver. Au total cependant, pour l'ensemble des sites, il n'existe pas de différence significative entre les nombres globaux correspondant à chacune des deux périodes. Le degré de fréquentation de certains sites peut donc varier saisonnièrement, entre autre selon qu'il s'agit d'aires d'alimentation, de repos, d'attente avant d'avoir accès à des tas de céréales, puis selon que la couverture de neige empêche ou non l'alimentation au sol en hiver.

2) Secteur de l'autoroute Bonaventure

À l'autoroute Bonaventure, la distribution des activités est très différente (Tableau 5). La majorité des pigeons (84,5%) sont installés sur les piliers de l'autoroute qui servent de dortoir et de site de nidification. Durant le jour, les pigeons qui s'y trouvent occupent un nid ou sont simplement perchés. Contraire-

TABLEAU 4. Répartition des nombres de pigeons dénombrés dans le secteur du Vieux Port en fonction de leurs activités

	Ensemble des données (n[1] = 105)		27 mai–16 octobre (n = 81)		17 octobre–16 mars (n = 24)	
Catégories d'activités	Nombre moyen[2]	% du nombre total moyen	Nombre moyen[2]	% du nombre total moyen	Nombre moyen[2]	% du nombre total moyen
Au repos et perchés	690 ± 267	60,4	632 ± 216	55,9	885 ± 329	75,1
S'alimentant	223 ± 168	19,5	216 ± 162	19,1	246 ± 186	20,9
Au repos au sol	196 ± 175	17,1	243 ± 171	21,5	35 ± 40	3,0
Au nid	14 ± 7	1,2	15 ± 6	1,3	10 ± 5	0,8
En vol	19 ± 52	1,7	24 ± 58	2,1	3 ± 12	0,3
Total	1142 ± 339	100	1130 ± 311	100	1179 ± 427	100

[1]n = nombre de parcours du trajet comportant 21 sites dans le Vieux Port.
[2]± écart-type

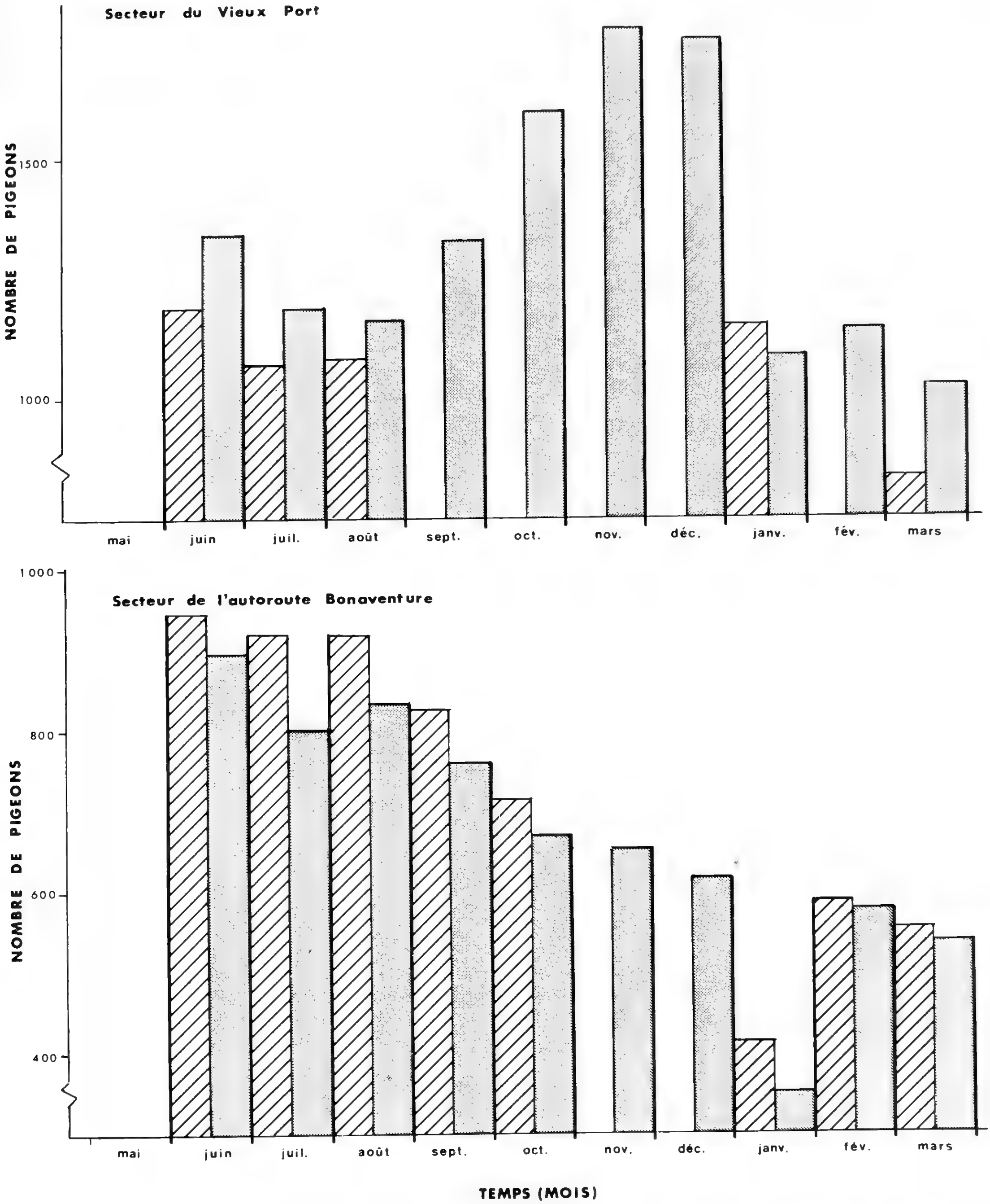

FIGURE 3. Variations mensuelles du nombre moyen de pigeons vus lors des trajets d'observation dans les secteurs du Vieux Port et de l'autoroute Bonaventure. Les colonnes obscures correspondent aux trajets effectués à 10:00, 12:00, 14:00 et 16:00; les colonnes claires (constituées de lignes parallèles inclinées) tiennent compte des trajets effectués plus tôt et plus tard (voir méthodes).

TABLEAU 5. Répartition selon différentes catégories d'activités des pigeons recensés lors des trajets d'observation réalisés dans le secteur de l'autoroute Bonaventure

		Ensemble des données (n[1] = 113)		27 mai - 15 octobre (n = 74)		16 octobre 1981 - 19 mars 1982 (n = 39)	
Catégories de sites[2]	Activité	Nombre moyen de pigeons ± e.-t.[3]	% du nombre total moyen	Nombre moyen de pigeons ± e.-t.	% du nombre total moyen	Nombre moyen de pigeons ± e.-t.	% du nombre total moyen
Ensemble de piliers	Au nid ou au dortoir	672 ±224	84,5	792 ±145	86,2	428 ±140	78,0
Au sol, sous les piliers	Surtout au repos, parfois s'alimentant	10 ± 19	1,3	3 ± 6	0,3	25 ± 26	4,6
Dans les parcs (sites H3, H4, H5 et H6)	Au repos ou s'alimentant	42 ± 49	5,3	60 ± 49	6,5	6 ± 22	1,1
Près de l'entrepôt (site H7)	15/16 s'alimentant 1/16 perché	16 ± 31	2,0	23 ± 36	2,5	2 ± 7	0,4
Près du silo (sites H1 et H2)	41/55 perchés 13/55 s'alimentant 1/55 au repos	55 ± 53	6,9	40 ± 34	4,4	87 ± 70	15,9
Total	Majorité au dortoir ou au nid	795 ±225	100	918 ±141	100	548 ±138	100

[1]n = nombre de parcours des piliers, édifices, parcs et terrains vagues du secteur de l'autoroute Bonaventure
[2]Les sites H1 à H7 sont indiqués à la figure 1
[3]Ecart-type

ment au secteur du Vieux Port, il ne s'agit pas d'oiseaux en attente à proximité d'une source de nourriture; près des piliers de l'autoroute, sauf exceptions, la disponibilité de ressources alimentaires suffisantes manque et les dérangements humains majeurs y sont de toute façon peu fréquents. Le nombre d'individus vus sur les piliers est moins élevé après le 16 octobre qu'auparavant (t de Student = 31,17, dl = 116, $p < 0,01$). Cela, comme nous l'avons vu plus haut, peut être dû à une dispersion vers d'autres secteurs, en particulier vers les environs du silo n° 5 dans le Vieux Port, à la mortalité accrue dans les grands froids (pigeons trouvés morts sous les piliers; voir plus haut), puis à la diminution en hiver des activités de nidification, même si plusieurs indices de leur nidification ont été obtenus.

Les environs d'un silo (sites H1 et H2; Figure 1) et d'un entrepôt (site H7) sont, dans le secteur de l'autoroute Bonaventure, les seuls endroits à compter quelques amas de céréales. A proximité du silo, contrairement à la situation qui prévaut près de l'entrepôt où les pigeons ne sont que rarement dérangés, le comportement des pigeons ressemble à celui observé dans le secteur du Vieux Port puisque la majorité d'entre eux sont vus perchés en attente d'une occasion de s'alimenter. Sous l'autoroute (1,3%) ou dans les parcs adjacents (5,3%; sites nos H3, H4, H5 et H6; Figure 1), on ne voit que des pigeons au repos sur le sol ou cherchant quelque nourriture à travers les mauvaises herbes; Potvin et al. (1976), Pierson (1976) et Moeed (1975) ont de fait remarqué que les pigeons consomment des graines de mauvaises herbes.

Quoique faible, la fréquentation de ces milieux varie cependant saisonnièrement. A cause de la couverture de neige ou de glace au sol, les parcs (test U de Mann-Whitney = 185,0, $p < 0,001$) et les environs de l'entrepôt ($U = 432,0$, $p < 0,001$) sont moins fréquentés en hiver. Par contre, aux environs du silo (sites H1 et H2: $U = 765,5$, $p < 0,001$) et au sol sous les piliers ($U = 411,5$, $p < 0,001$), on constate le contraire. Les céréales perdues lors des transbordements du grain dans les environs du silo constituent en hiver pratiquemment la seule ressource alimentaire pour les pigeons du secteur de l'autoroute. Finalement, l'absence de neige au sol pendant l'hiver sous l'autoroute leur permet de s'y adonner aux activités de cour et fait de ce milieu pratiquement le seul endroit où ils peuvent trouver des matériaux pour la construction des nids.

Conclusion

La fraction visible des pigeons des secteurs du Vieux Port et de l'autoroute Bonaventure est estimée à quelque 2000 individus. A cela peuvent s'ajouter entre 200 et 600 pigeons dissimulés dans des bâtiments ou non visibles lors des itinéraires d'observation.

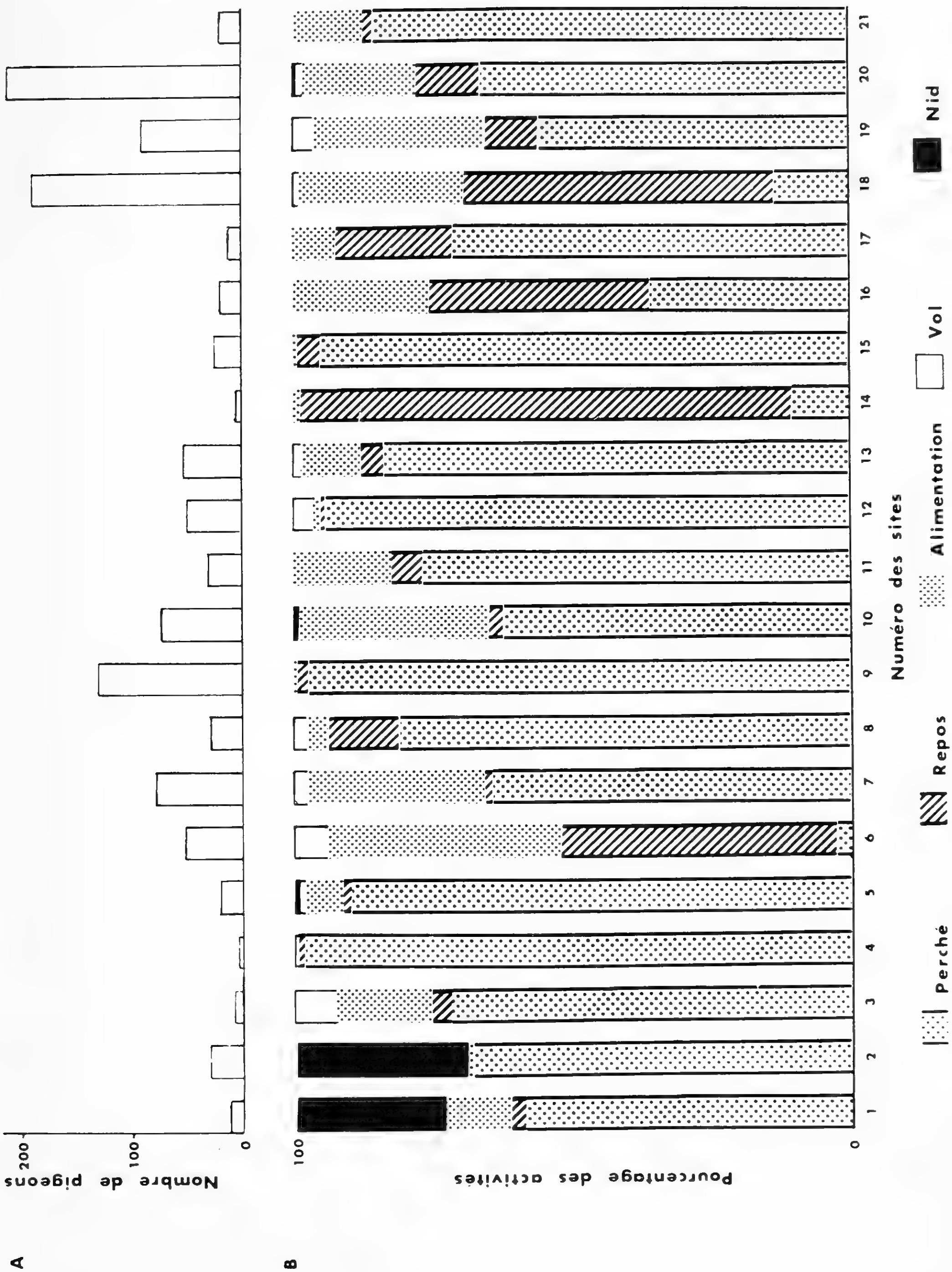

FIGURE 4. (A) nombre total moyen de pigeons dénombrés à chaque site d'observation du secteur du Vieux Port; (B) répartition de ce nombre en pourcentage en fonction des activités.

Le nombre de pigeons visibles varie selon les saisons et les périodes de la journée (répartition bimodale). Dans le secteur du Vieux Port, il est plus élevé à l'automne (immigration de pigeons d'autres secteurs qui se regroupent à proximité des principales sources d'alimentation) et l'après-midi (lorsque les pigeons s'alimentent). Dans le secteur de l'autoroute, le nombre de pigeons observés diminue de juin à janvier et est plus faible l'après-midi (lorsque plusieurs vont s'alimenter ailleurs). La diminution marquée du nombre de pigeons observés en hiver peut s'expliquer en partie par une augmentation du taux de mortalité suite aux grands froids.

La majorité des pigeons sont observés perchés, mais leurs activités sont surtout reliées aux caractéristiques physiques des lieux où leur nombre varie selon la proximité ou la disponibilité de sources d'alimentation (grains épars au sol) associées à la présence de structures qui servent de perchoirs. Plusieurs s'alimentent dans le port mais ils y sont souvent dérangés, surtout durant les heures de travail, par les activités de manutention et de déchargement des céréales. En été, les pigeons peuvent se concentrer au sol en des aires de repos mais ce phénomène est plus rare en hiver. Des nids actifs ont été vus durant toute l'année. Quand vient l'hiver, le nombre d'individus augmente à certains sites et diminue à d'autres; cette redistribution dépendrait surtout de la couverture de neige qui limite l'accès aux céréales répandues au sol.

Remerciements

Nous remercions tous ceux qui de près ou de loin ont contribué à la réalisation du présent travail, en particulier Louise Desrochers, Elise Mayrand, Johanne Winner, François Lévesque, Hélène Rocheleau et René Tridemy pour l'aide fournie lors de la cueillette des données, André Dupré pour les photographies de la figure 2, Jean Burton, Alain Leduc, Normand David, Pierre Mousseau et Claire Léger du Centre de recherches écologiques de Montréal, Pierre Robert et G. Lamoureux du département d'informatique et de recherche opérationnelle de l'Université de Montréal, Anthony J. Erskine du Service canadien de la Faune et Henri Ouellet du Musée national des Sciences naturelles pour leur aide lors de la conception de l'étude, lors du traitement statistique et de l'analyse des données, ou lors de l'élaboration de la version finale du manuscrit.

Notre étude n'aurait pas été possible sans la collaboration de G. Heppel, V. Gendron, C. L. Germain et N. Rasmussen de l'Administration du port de Montréal qui ont facilité le travail sur le terrain.

Cette recherche a été poursuivie grâce à une bourse du Conseil de recherche en sciences naturelles et en génie dont a bénéficié le premier auteur et elle a été financée partiellement par le Musée national des Sciences naturelles, Musées nationaux du Canada, dans le cadre des programmes d'emploi d'été des jeunes d'Emploi et Immigration Canada.

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Reçu le 24 janvier 1984
Accepté le 19 novembre 1984

Distributional Records of Rock Voles, *Microtus chrotorrhinus*, in Northeastern Minnesota

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Christian, Donald P., and Jeanne M. Daniels. 1985. Distributional records of Rock Voles, *Microtus chrotorrhinus*, in northeastern Minnesota. Canadian Field-Naturalist 99(3): 356–359.

The Rock Vole (*Microtus chrotorrhinus*) had been reported in Minnesota from only three widely separated localities. During 1980, 1981, and 1982 we captured Rock Voles at 59 new localities in northeastern Minnesota establishing that the species is much more common and widespread in the region than previous records indicated. The new sites represent diverse vegetation types and successional stages; boulders and crevices were present at all sites, but the significance of these features for Rock Voles remains unclear. Our results suggest that Rock Voles occur in northeastern Minnesota in discontinuous, small, and localized populations.

Key Words: Rock Voles, *Microtus chrotorrhinus*, distribution, Minnesota.

The Rock Vole, *Microtus chrotorrhinus*, reaches the western-most limit of its geographic range in northeastern Minnesota. The first record of Rock Voles in Minnesota was of one specimen collected in northern St. Louis County in 1921 (Handley 1954; Swanson 1945). This remained the sole record of *M. chrotorrhinus* in the state until the 1970's, when Rock Voles were captured at two localities in Cook County, in extreme northeastern Minnesota (Buech et al. 1977; Timm 1974; Timm et al. 1977). As a result of the extreme paucity of distributional records and the unusual pattern of discovery of Rock Vole populations in Minnesota, the status of this species in the state has been of considerable interest.

During 1980, 1981, and 1982, we captured 98 Rock Voles at 59 new localities in Cook County, increasing to 61 the number of recent distributional records in the state. These results are important because they alter previous thoughts about the extreme rarity of Rock Voles in this region, and because they provide information about habitat relationships in this portion of the species' range.

Sites were selected for sampling based on the presence of surface boulders and rock crevices (see Kirkland and Jannett 1982). Snap traps (10–50 per site, depending on area of suitable habitat) baited with rolled oats and peanut butter were used in the sampling. Whenever possible, traps were placed in subsurface runways (i.e., in crevices). In 1980 and 1981, traps were set for two or three nights; in 1982, traps were removed from a site upon capture of the first Rock Vole or at the end of two days and nights of trapping. Our methods thus were designed to detect presence of Rock Voles and not to estimate density. Trapping was conducted on the following dates (number of sites sampled in parentheses): 1980 August 11–13, 15–17, and 21–23 (5); 1981, September 8–11 (2); 1982, August 6–8 (8), September 4–6 (8), 23–26 (21), and 30–October 2 (27, including 2 previously trapped sites where Rock Voles had not been captured). At least one voucher specimen for each locality is deposited in the Bell Museum of Natural History, University of Minnesota.

New localities at which Rock Voles were captured are shown in Figure 1. Detailed locality information is available from the senior author or from the Depository of Unpublished Data. Some of the new Rock Vole localities are in close proximity to one another or are only a short distance from the locality described by Timm (1974). Treatment of these sites as separate localities warrants comment. All adjacent sites were separated from each other by qualitatively different, non-rocky habitat, and thus represent discrete habitat "patches". Different portions of a single boulder field were not treated as distinct localities, nor were portions of a single boulder system bisected by a highway.

Included in the new sites are the eastern-, western-, and southern-most records of Rock Voles in Minnesota. Areas in extreme eastern and in northwestern Cook County were not sampled, but it is likely that Rock Voles occur throughout much of these areas. We did not observe suitable habitat for Rock Voles in the portion of Cook County south of our sampling sites, and it is possible that sites shown in Figure 1 at least approach the southern limit of Rock Voles in the state. However, our surveys included only readily accessible roadside sites, and suitable habitat may be present in this region in more isolated locations.

Southern Red-backed Voles (*Clethrionomys gapperi*) were the most common small mammals co-occurring with Rock Voles. This species, which was captured at 52 (88%) of the sites where Rock Voles were found, was frequently caught in the same subsurface runways as Rock Voles, a result reported by

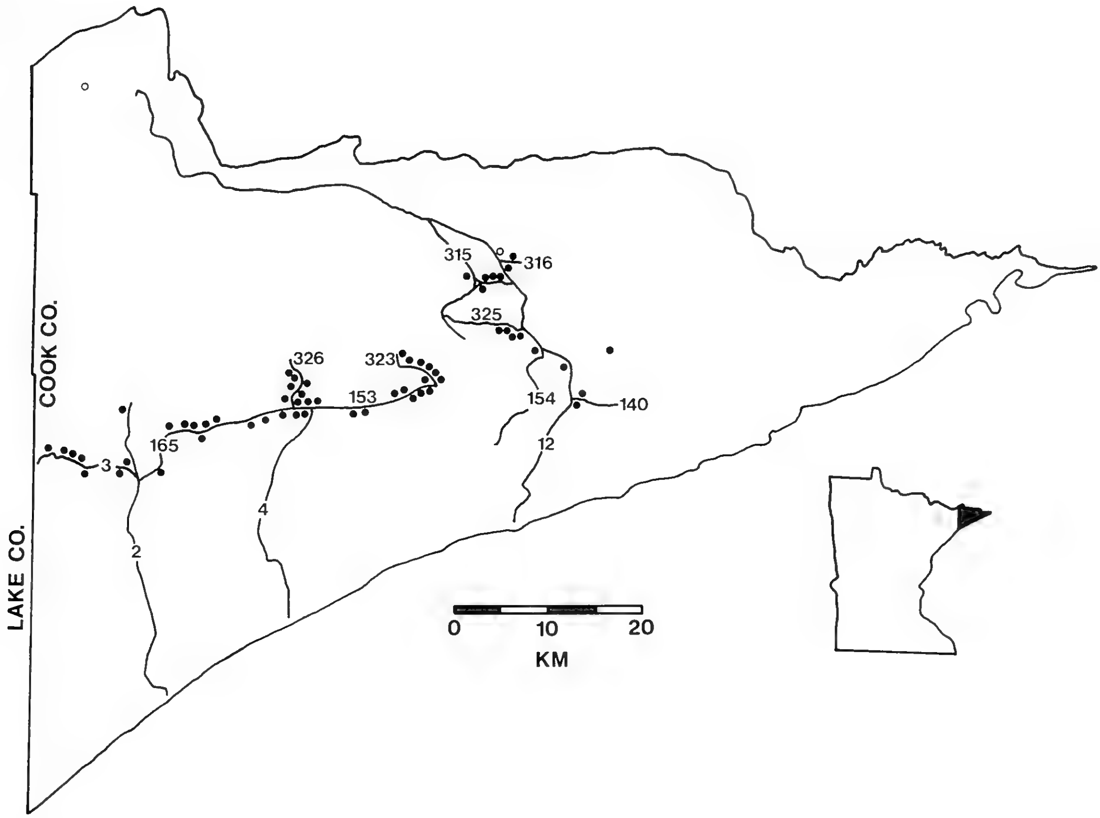

FIGURE 1. Map of Cook County, Minnesota, showing localities where Rock Voles were captured during 1980, 1981, and 1982 (closed circles); open circles indicate Rock Vole localities of Buech et al. (1977) and Timm (1974). Numbers identify Cook County and USDA Forest Service roads.

other authors (Kirkland and Jannett 1982; Timm et al. 1977). Martin (1971) reported a relatively constant ratio of 3 *C. gapperi* per *M. chrotorrhinus*; Kirkland (1977) and Kirkland and Knipe (1979) observed ratios of about 2.8 and 2.0, respectively, in West Virginia and New York. In the present study, the overall ratio of Red-backed Vole: Rock Vole numbers was 1.40 (137/98), and Red-backed Vole numbers exceeded those of Rock Voles at only 19 of the 59 sites. Thus, the relative abundance of Rock Voles observed in this study appears to have been higher than previously reported.

Peromyscus maniculatus, Blarina brevicauda, and *Sorex cinereus* were commonly observed at Rock Vole sites (29%, 20%, and 17% of the localities, respectively). Other small mammals captured at Rock Vole localities included *Sorex palustris* (1 site), *Eutamias minimus* (3), *Napeozapus insignis* (1), *Synaptomys cooperi* (2), and *Microtus pennsylvanicus* (2). The extent to which habitat distribution of Rock Voles is influenced by interactions with Southern Bog Lemmings (*S. cooperi*) or Meadow Voles (*M. pennsylvanicus*) is not known (see Timm et al. 1977). In that context, it is significant that these other two microtine rodents appear to coexist with *M. chrotorrhinus* at relatively few sites in northeastern Minnesota.

As described above, potential sampling sites were selected on the basis of presence of exposed rocks. This common feature of Rock Vole localities reported in this study was thus determined *a priori.* Nonetheless, presence of boulders was highly predictive of presence of *M. chrotorrhinus:* 59 of 69 (86%) sites characterized by boulders produced Rock Voles, regardless of vegetative composition. These sites included reasonably extensive boulder fields (about 39% of localities); the surface area of exposed boulders at these sites was generally 0.4–0.5 ha (40–50 × 100 m) or more. A large percentage (47%) of

the new localities is represented by only small (many less than about 15-m diameter) pockets of exposed boulders. Rock crevices, although variable in number and depth, were present at all sites, and most *M. chrotorrhinus* were captured in traps placed in crevices, often as much as 40–50 cm below the ground surface. Most sites were moist-to-wet, although standing or running water was present at only about 40% of the localities (see Kirkland and Knipe 1979; Martin 1971).

The most common tree species at Rock Vole sites were Black Spruce (*Picea mariana*), found at about 75% of the localities, and Paper Birch (*Betula papyrifera*), which occurred at about 60% of the sites. Aspen (*Populus tremuloides*), White Cedar (*Thuja occidentalis*), and Balsam Fir (*Abies balsamea*) were frequently present. About two-thirds of the sites had moderately open canopies, and only a few (13%) were characterized by dense canopy. The sapling/tall shrub layer at most sites was sparse to only moderately dense; this layer commonly consisted of alder (*Alnus* sp.), hazel (*Corylus* sp.), willow (*Salix* sp.), or small conifers, especially *P. mariana* and *A. balsamea*. Eleven sites showed signs of disturbance in the form of logging, burning, or clearing for human dwellings or railroad rights-of-way.

The only ground- and low shrub-layer plants found at a large number of the new rock vole localities were Bunchberry (*Cornus canadensis*), found at 67% of the sites, and Blueberry (*Vaccinium angustifolium*), observed at about 52% of the localities. Other common plant species in this stratum were Raspberry (*Rubus* sp.), Labrador Tea (*Ledum groenlandicum*), Twinflower (*Linnaea borealis*), Large-leafed Aster (*Aster macrophyllus*), and Clinton's Lily (*Clintonia borealis*). There was considerable variation among sites in density of ground- and low shrub-layer vegetation. A substantial number of sites (respectively, about 32%, 42%, and 26% of sites) was represented by sparse, moderately dense, and dense vegetation in this layer.

Two particular ground-cover types warrant special comment. One of these is characterized by extremely thick, moist moss cover (primarily *Sphaghum*). Although moss is present at virtually all sites, ground cover at these localities is strongly dominated by moss, and forb cover is extremely sparse. These areas are commonly associated with mature Black Spruce forests. Although crevice abundance at these sites is low, scattered crevices may be found between the thickly moss-covered boulders. Wind-downed trees are common at many of these sites, and exposed boulders and crevices are visible under the upturned roots of these trees. This habitat type has generally been overlooked in surveys of Rock Voles, at least in northeastern Minnesota, probably due to the sparseness of forb cover. However, *M. chrotorrhinus* were found at 11 of 14 (79%) such sites sampled in the present study, suggesting frequent use of this habitat by Rock Voles.

The other ground-cover type deserving mention is that with a major grass/sedge component. Ten (17%) sites sampled during this study fall into this category. Of these, four sites have sufficiently dense grass or sedge cover to be considered almost "meadow" habitats, although they also contain a significant shrub component. These sites are of interest because, like the moss-dominated localities described above, they are qualitatively very different from habitats where Rock Voles have previously been reported in northeastern Minnesota (Buech et al. 1977; Timm 1974). Furthermore, these habitats may warrant particular attention because they probably represent highly suitable habitat for *M. pennsylvanicus* and may thus provide likely arenas for interaction between *M. chrotorrhinus* and Meadow Voles.

This study has shown that suitable Rock Vole habitat, and populations of Rock Voles, occur in northeastern Minnesota at much higher frequency than previous records indicate. However, results of this study suggest that Rock Vole habitat in this region is quite discontinuous. As a result, the species is represented by small, localized populations occurring in fairly restricted habitat "islands". A high percentage of the new localities was represented by extremely small patches of boulders. This is significant because it is questionable whether these small habitats can support viable populations of Rock Voles from year to year. Although this "insular" habitat distribution has not been emphasized in the published literature on Rock Voles, it appears to be common throughout the species' range, and further research is needed to understand the demographic implications of this pattern.

It is clear that Rock Voles are much more specialized in their habitat selection than, for example, Red-backed Voles. Nonetheless, Rock Voles were captured in a wide diversity of habitats, reflecting variation in general habitat type as well as in plant species composition and density. This result supports the suggestion of Kirkland and Knipe (1979) that this species has greater ecological generality than previously thought. The occurrence of Rock Voles in disturbed habitats has been reported previously (Kirkland and Jannett 1982 and references cited therein), but this species' relationship to forest succession is not well understood. Thus, further research is needed on the impact of forest-management practices and natural disturbance on habitat quality for this species. Additionally, although *M. chrotorrhinus* appears to be closely asso-

ciated with rocky habitats, the significance of rocks and crevices remains unclear, and the extent to which they occur in non-rocky habitats is unknown.

Acknowledgments

This research was supported by funds provided to JMD in 1980 by the Minnesota Natural Heritage Program, Sigma Xi, and the Wilke Fund, in 1981 by the Minnesota Department of Natural Resources (MDNR) Nongame Program, and to DPC in 1982 by the MDNR Nongame Program and the University of Minnesota Graduate School. We are indebted to the numerous field assistants who helped with trapping and specimen preparation.

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Received 12 January 1984
Accepted 18 October 1984

Addendum: On 14 October 1984, a *Microtus chrotorrhinus* was captured by G. Mielke in a marsh about 5 m from the boulder-strewn south shore of Rock Island Lake, Lake County, Minnesota (T. 63N, R. 9W, sec. 33). This locality is approximately 35 km W of the western-most Cook County locality described above, and represents the first record of Rock Voles in Lake County. This specimen is deposited in the Bell Museum of Natural History, University of Minnesota.

Received 30 October 1984

Researchers Please Note

The Nongame Research Program of the Minnesota Department of Natural Resources (DNR) is sponsoring long-term research (-1989) on populations of the Rock Vole (*Microtus chrotorrhinus*) in northeast Minnesota at numerous sites, including many of those reported by Christian (1985 *Canadian Field Naturalist* 99(3): 356–359). The DNR would appreciate these sites not being distrubed by trapping activity. Anyone contemplating trapping activity in Cook County, Minnesota, is respectfully requested to contact one of these two persons beforehand: Lee Pfannmuller, Nongame Research Program, DNR, Box 7, 500 Lafayette Road, St. Paul 55146, (612) 297-2276; Fred Jannett, Science Museum of Minnesota, St. Paul 55101, 221-9429. Thank You.

FREDERICK J. JANNETT, JR.

27 March 1985

Simultaneous Multinesting by the Fourspine Stickleback, *Apeltes quadracus*

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Courtenay, Simon C. 1985. Simultaneous multinesting by the Fourspine Stickleback, *Apeltes quadracus*. Canadian Field-Naturalist 99(3): 360–363.

The Fourspine Stickleback, *Apeltes quadracus*, may tend more than one nest at a time while breeding in the laboratory. No other stickleback species is known to do this. I examined the phenomenon of multinesting in nature and found it to be common. Half the males observed nesting in the field were tending two or more nests scattered throughout their territories. Multinesting males with several clutches of eggs in their care distributed the clutches among their nests. Multinesting may be a response to the pressures of egg predation in the complex and variable intertidal zone.

Key Words: *Apeltes quadracus*, Fourspine Stickleback, nesting, reproductive behaviour, antipredator strategy, egg-stranding, New Brunswick, habitat selection, intertidal fish.

Reproductive behaviour of the sticklebacks (family Gasterosteidae), particularly that of the Threespine Stickleback, *Gasterosteus aculeatus*, has attracted much interest among ethologists (Wootton 1976). Less well described is the behaviour of the smallest member of the family, the Fourspine Stickleback, *Apeltes quadracus*. This species is found only on the east coast of North America, from Newfoundland to Virginia (Krueger 1961; Leim and Scott 1966; Wootton 1976). Like all sticklebacks, Fourspine Stickleback males establish territories and build small nests of pieces of algae and other plant matter cemented together with a kidney secretion. Like the Ninespine (*Pungitius pungitius*), Fifteenspine (*Spinachia spinachia*), and Brook Sticklebacks (*Culaea inconstans*), Fourspine Sticklebacks generally build nests on or between the stems of aquatic plants (Hall 1956; Rowland 1974; Courtenay 1983). The male then courts a female, induces her to spawn a clutch of 15 to 50 eggs in the nest (Hall 1956; Schwartz 1965; Rowland 1974; Wallace and Selman 1979; Craig and FitzGerald 1982), and having chased the female away, cares for the eggs until they hatch. Parental care consists primarily of nest ventilation, which in this species is accomplished by sucking water through the nest (Breder 1936; Reisman 1963; Rowland 1970). A male may tend up to four or five clutches (from different females) at any one time. These clutches are either placed one above another in separate compartments of a single "apartment style" nest (Ryder 1881; Breder 1936; Hall 1956; Reisman 1963; Rowland 1974) or are distributed among several nests scattered throughout the male's territory (Hall 1956; Rowland 1970; Blouw and Hagen 1981). The Fourspine Stickleback is the only stickleback reported to tend more than one nest at a time, and these reports are all from aquarium studies. This paper examines the incidence of Fourspine Stickleback multinesting at one natural breeding site.

Materials and Methods

Nesting male Fourspine Sticklebacks were observed and nests were collected from 15 May to 30 June 1981 from Sam Orr Pond, a shallow 8 ha tidal lagoon, 12 km northeast of St. Andrews, New Brunswick. I lay in the water wearing a wetsuit, mask and snorkel, and watched individual males tending their nests. After noting the attachment site of each of a male's nests, the nests were collected and taken back to the Huntsman Marine Laboratory in St. Andrews, where I recorded the number of clutches and eggs per nest, and per male. A clutch is the number of eggs deposited by one female at one time. Clutches were distinguishable as spherical groups of adhering eggs. Clutch size is probably somewhat underestimated here, since the eggs of some clutches of advanced development had begun hatching (approximately 10% of the clutches examined) and some larvae had left their nests.

Results

Seventy-four of 85 male Fourspine Sticklebacks observed were nesting on the four most common vegetation types in Sam Orr Pond — Rockweed (*Fucus vesiculosus*), Rockweed covered with brown filamentous algae (probably *Pylaiella littoralis*), *Enteromorpha intestinalis*, and Eelgrass (*Zostera marina*). There was no significant difference in the number of nests per male across these four vegetation types ($P > 0.05$, ANOVA, data $X^{-0.81}$ transformed).

The modal number of nests per male was one, but about half the 85 males sampled were tending two or more nests (Figure 1). Some of these multinesters tended nests placed close together (e.g. in a single strand of *Enteromorpha*), while others, nesting in Eelgrass beds for instance, tended nests over a wider area. For 31 multinesting males, the distance between nests belonging to the same male ranged from 2 to 40 cm, averaging 14.5 ± 0.9 cm (S.E., n = 41). Nests belonging to the same male were generally built on the same vegetation type or on the same substrate (rocks, gravel, shells or mud). Of 38 multinesting males nesting in areas offering a variety of potential nest sites, only eight used more than one type of attachment site ($P < 0.001$, Binomial Test).

Sampled males were tending from zero to four clutches of eggs, the mode being one clutch per male (Figure 2). Mean clutch size for this population was 16.3 ± 0.9 eggs (S.E., n = 90). On average, multinesting males were tending significantly more clutches and eggs than were males with single nests (Table 1). Multinesting males with more than one clutch distributed the clutches throughout their nests; of 19 multinesting males having two or more clutches, 17 used two or more nests to house them ($P < 0.001$, Binomial Test).

Discussion

Several laboratory studies have reported male Fourspine Sticklebacks tending more than one nest simultaneously (Hall 1956; Rowland 1970). This study confirmed that multinesting is common in nature. Considering that males sampled in the field were at various stages of the reproductive cycle, and that some of their nests may have been overlooked, multinesting may be even more common than indicated by this study (i.e. 50%). There was no indication that multinesting was associated with particular types of vegetation or substrate; some of the males nesting in all of the common vegetation types and over all substrate types in Sam Orr Pond displayed multinesting. Nor did males fill one nest with eggs, and then build another as suggested by Hall (1956). Often, several nests were built before any eggs were acquired.

Aquarium studies report individuals of this species

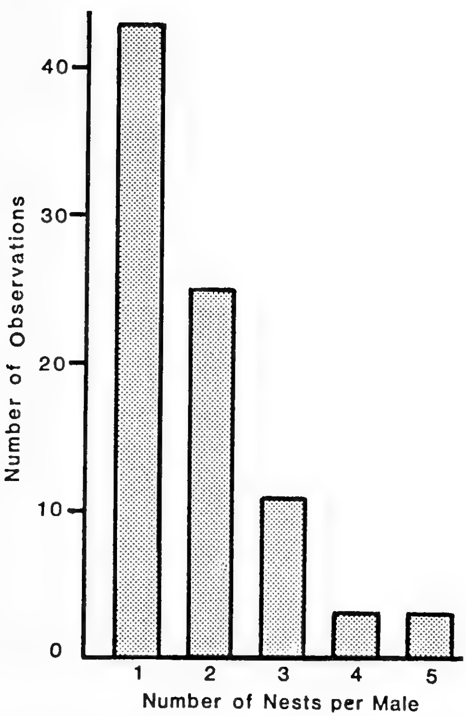

FIGURE 1. Histogram of the number of observations for each number of nests tended by a male Fourspine Stickleback.

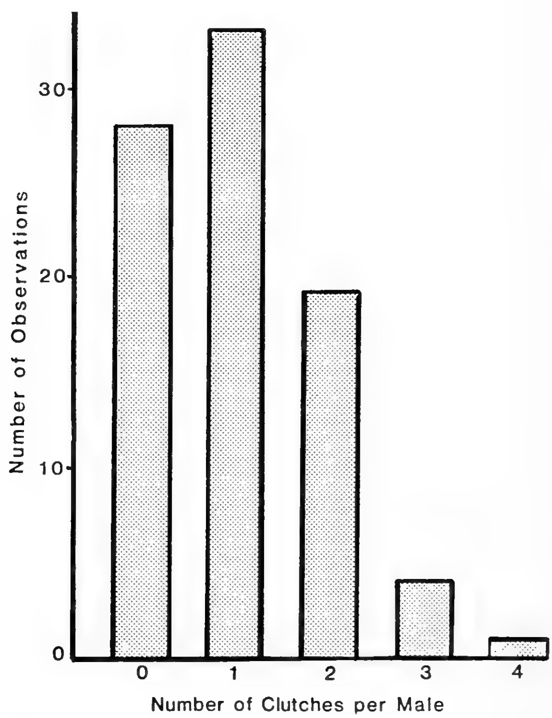

FIGURE 2. Histogram of the number of observations for each number of clutches tended by a male Fourspine Stickleback.

TABLE 1. The number of clutches and eggs acquired by single and multinesting male Fourspine Sticklebacks (mean ± 1 standard error, ** = $P < 0.01$, ANOVA).

Males	N	Number of clutches	Number of eggs
Single Nesters	43	0.628 ± .105	12.2 ± 2.1
		**	**
Multinesters	42	1.429 ± .149	21.0 ± 2.5

build and maintain "apartment style" single nests, which house all of the clutches acquired by the male in separate sections (Breder 1936; Hall 1956). I did not observe this in Sam Orr Pond, but I did observe it in a nearby small tidal pool which was devoid of vegetation, and where the density of nesting Fourspine Sticklebacks was relatively high. I suspect that "apartment style" nesting is an adaptation to restricted territory size and/or number of nest attachment sites (as found in the tidal pool and in aquaria), and that in nature multinesting is the rule, not the exception for this species.

In this respect, the Fourspine Stickleback is unique among sticklebacks. For male Threespine Sticklebacks, the presence of a single large egg-filled nest is important in attracting females to spawn (Ridley and Rechten 1981). This study showed that multinesting male Fourspine Sticklebacks were tending more clutches and eggs than single nesters were (Table 1), and these clutches were distributed among the males' nests, not concentrated in one. It may be that unlike Threespine Sticklebacks, female Fourspine Sticklebacks are more attracted by an empty nest than one already containing eggs.

There are at least two possible advantages to multinesting. First, interclutch transmission of disease or fungus is eliminated. In my examination of clutches I found few unhealthy eggs, but Hall (1956) observed male Fourspine Sticklebacks removing infected eggs from nests in the laboratory. Second, and perhaps more important, multinesting may reduce egg predation. The extent of predation on Fourspine Stickleback eggs is unknown, but Blouw and Hagen (1981) list American Eels (*Anguilla rostrata*), Killifish (*Fundulus*), Atlantic Tomcod (*Microgadus tomcod*), Ninespine, Threespine and Blackspotted (*G. wheatlandi*) Sticklebacks and conspecifics as potential egg predators. These, as well as Atlantic Silversides (*Menidia menidia*) and Rock Crabs (*Cancer irroratus*) which might also eat Fourspine Stickleback eggs, were all present in Sam Orr Pond during the breeding season of the Fourspine Stickleback. Male Fourspine Sticklebacks are smaller than any of these potential egg predators (except conspecifics), and might therefore be expected to rely on "hiding" their nests, rather than overtly defending them. Several small single-clutch nests spread throughout a male's territory should present less of a target to egg predators (both visually and chemically) than one large multiclutch nest with the male in constant attendance. Even if one of several nests was detected by a predator, the loss would be only one clutch of eggs rather than all the clutches acquired by the male.

One further field observation supports the suggestion that egg predation may be an important consideration in Fourspine Stickleback nesting behaviour. Several times I have found Fourspine Stickleback nests on the banks of intertidal pools, exposed to the air at low tide, but at high tide submerged and tended by males. The nests contained eggs which appeared to develop normally (though I did not observe hatching). Egg-stranding may be a response to crowding in such pools, but Taylor, Di Michele and Leach (1977) observed a similar behaviour by another intertidal fish, the Mummichog (*Fundulus heteroclitus*), and offered another explanation. They point out that among other potential advantages, such eggs are less exposed to aquatic predators. Possibly egg-stranding and multinesting by the Fourspine Stickleback are antipredator strategies.

Acknowledgments

I wish to thank Dr. M. H. A. Keenleyside for advice on the preparation of this manuscript, and Hélène Dupuis, Greg Goff, Doug Noltie and two anonymous referees for helpful comments on earlier drafts. I am grateful to the Huntsman Marine Laboratory for providing lab space. This work was part of a larger project supported by an N.S.E.R.C. operating grant to M.H.A.K. and an N.S.E.R.C. postgraduate scholarship to S.C.C.

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Received 6 January 1983
Accepted 13 January 1984

Notes

The Judith Underwing Moth, *Catocala judith*, in Ontario

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Kamstra, James. 1985. The Judith Underwing Moth, *Catocala judith*, in Ontario. Canadian Field-Naturalist 99(3): 364.

The Judith Underwing Moth, formerly known in Canada from a single male collected near Montreal in 1901, is reported from three sites in Ontario: near Harrow, Essex County; near Caledonia, Haldimand-Norfolk Region Municipality; and Mallorytown Landing, Leeds County.

Key Words: Judith Underwing Moth, *Catocala judith*, distribution, Ontario.

Before 1978, the Judith Underwing (*Catocala judith* Strecker) was known in Canada from only one old record, a male was collected by A. E. Norris near Montreal in July 1901 (J. D. Lafontaine, personal communication). Sargent (1976) has described the range of *C. judith* as: "New Hampshire, S. Ontario and Michigan south to North Carolina and westward". The assumed occurrence of the moth in Ontario was not based on any definite records however (Lafontaine, personal communication), yet it had been collected in three Michigan counties adjacent to the Canadian border (Moore 1955). This note reports new records from three sites in southernmost Ontario.

Jack Pilkington has observed *C. judith* at sugar bait in an oak (*Quercus sp.*)-hickory (*Carya sp.*) woodlot near the village of Harrow, Essex County on five occasions: 3 (several), 5 (several), 14 (one) August 1978; 8 (five) and 9 (one) August 1980. Surprisingly, he did not find any at this site in 1981 or 1982 despite extensive baiting (J. E. Pilkington, personal communication).

Single specimens have been found at two other sites. Jim Troubridge collected a male *C. judith* at a light trap near Caledonia, Haldimand-Norfolk Regional Municipality on 29 July 1980. I collected a female *C. judith* at Mallorytown Landing, St. Lawrence Islands National Park, Leeds County on 30 August 1981. This moth was attracted to a mercury vapour lamp, about midnight on a warm (21°C.), humid, breezy night. The nearby woodlands contain a large proportion of Shagbark Hickory (*Carya ovata*), the main foodplant of the larva of *C. judith* (Sargent 1976). The specimens from Caledonia, Mallorytown Landing and several from Harrow are in the Canadian National Collection, Biosystematics Research Institute, Central Experimental Farm, Ottawa.

It is unknown whether the sudden appearance of this moth indicates a recent range expansion or an increase of collectors in the field. The single specimens from Caledonia and Mallorytown Landing may be wanderers but the larger numbers observed at Harrow indicates the presence of a thriving population.

Acknowledgments

I would like to thank Jack E. Pilkington for his detailed observations, and Dr. J. Donald Lafontaine for his comments and information.

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Received 30 November 1983
Accepted 18 September 1984

Mammals, Birds, and Butterflies at Sodium Sources in Northern Ontario Forests[1]

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Wildlife seen at natural sodium-rich springs and at roadside pools contaminated by highway de-icing salt in northern Ontario included two species of wild ungulates, one species of rodent, three species of birds, and two species of butterflies. The three birds were finches of the sub-family Carduelinae, noted for feeding almost exclusively on plant material. The mammalian species were also herbivorous. Apart from Porcupines (*Erethizon dorsatum*), small mammals were rarely seen at the saltwater locations, perhaps because of their apparent preference to ingest salt in solid form rather than in water.

Key Words: Mammals, birds, butterflies, sodium, salt, feeding behavior.

Much of the forested area of northern Ontario is underlain by the granitic rocks of the Precambrian Shield and is relatively poor in environmental sodium (Na). Two significant sources of Na in that area are natural mineral springs and roadside pools contaminated by highway de-icing salt. Previously we have documented that Moose (*Alces alces*) and White-tailed Deer (*Odocoileus virginianus*) are attracted to such sites (Fraser and Hristienko 1981; Fraser and Thomas 1982). While doing those studies, my co-workers and I recorded observations of other mammals, birds, and butterflies at the saltwater sources.

Methods

One study was conducted on a 156-km section of the Trans-Canada Highway near Wawa, Ontario (48°N, 84°45′W). Each winter, de-icing salt (NaCl) is spread on the highway at an estimated rate of 30-40 tonnes/km. As a result, many pools of stagnant water near the roadside have a high Na content (100-600 ppm). Because the roadside areas are laden with salt, many pools are recharged with brine at each rainfall and show little tendency for Na levels to decline during the summer (Fraser and Thomas 1982). The study involved a selection of 56 such pools inspected every second day from 16 May to 10 August 1980. Evidence of Moose activity was recorded in detail (Fraser and Thomas 1982). Records were also kept on any other mammals, birds or aggregations of insects seen at the pools.

The second study involved two natural mineral springs (licks) in Sibley Provincial Park, Ontario (48°25′N, 88°45′W). Water in the licks contains 50-200 ppm Na plus high levels of some other minerals. A selection experiment at one site showed that Moose and White-tailed Deer at the lick were attracted specifically to Na (Fraser and Reardon 1980). The study included 1798 h of scheduled observations mainly between 0600 and 2100 EDT, between May and September of 1977-80. The observer normally watched from a tent pitched near the licks and recorded all visits by Moose and White-tailed Deer. Other users of the licks were also noted when seen, but the records likely underestimate the actual number of visits by the smaller species.

Results

Moose were seen 41 times at the roadside pools in the Wawa area, and tracks indicated regular use at many sites. White-tailed Deer, which were rare in the area, were seen only once at such pools, but tracks indicated several other visits. A Woodchuck (*Marmota monax*) was seen once, and Snowshoe Hares (*Lepus americanus*) were seen twice in or near pools, but their behavior at the sites could not be seen clearly. However, Woodchucks were frequently seen licking roadside gravel in the area during May and June.

Most sightings of birds at roadside pools were confined to three species: Evening Grosbeaks, Purple Finches, and Pine Siskins (Table 1). Those birds were commonly in groups of two or more, pecking in areas of damp soil near the salty water. Most sightings of these species were made in June and the first week of July. The few sightings of other bird species were probably unrelated to the high salt content of the pools, although Cedar Waxwings were occasionally seen pecking at mud in the pools.

Tiger Swallowtail butterflies (*Papilio glaucus*) were seen 58 times and White Admiral butterflies (*Limenitis arthemis*) three times at pools, usually on the damp

TABLE 1. Species of birds seen more than once at saltwater roadside pools in northern Ontario

Species	Number of sightings
Evening Grosbeak (*Coccothraustes vespertina*)	157
Purple Finch (*Carpodacus purpureus*)	56
Pine Siskin (*Carduelis pinus*)	48
Cedar Waxwing (*Bombycilla cedrorum*)	5
Ruffed Grouse (*Bonasa umbellus*)	2
Chipping Sparrow (*Spizella passerina*)	2

mud. No other butterfly species and no unusual aggregations of other insects were noted at the sites.

At the natural mineral licks, there were 260 visits by Moose and 134 by White-tailed Deer during scheduled observations in 1977–80 (Fraser and Hristienko 1981). In most cases the animals drank for long periods, mainly from the spring source area. Other mammals included 28 visits by Porcupines (*Erethizon dorsatum*) and two by Red Squirrels (*Tamiasciurus hudsonicus*). Unlike the ungulates, the Porcupines and Squirrels did not drink the mineral-rich water, but licked the surface of exposed mud and rocks where salty water had presumably evaporated. Black Bears (*Ursus americanus*), Red Foxes (*Vulpes vulpes*) and Snowshoe Hares were occasionally seen at licks, but they simply passed by without feeding or drinking. However, Snowshoe Hares and Porcupines were commonly seen licking roadside gravel in the Sibley area.

Purple Finches (49 sightings) and Pine Siskins (4 sightings) were seen at the licks. Generally they pecked bare mud in the lick area for many minutes at a time. There was no apparent use by other bird species. Evening Grosbeaks were not seen in the study area.

Tiger Swallowtail butterflies, often in aggregations of 5 to 10, were commonly seen on damp soil in the licks. No other butterflies and no aggregations of other insects were noted.

Discussion

In view of the high levels of Na in the licks and roadside pools, and the scarcity of this element in other parts of the environment, it seems likely that Na was the major attraction for the various types of wildlife recorded. Birds might use soil or gravel areas as a source of calcium or grit, but calcium is readily available in soil, and grit could be obtained easily from the large areas of bare gravel and soil near the roads. Hence, neither of these possibilities could likely explain the concentration of wildlife at the localized Na-rich sites.

Attraction to Na sources appears to be exceptional among insects. Only Tiger Swallowtail butterflies have a demonstrated attraction to Na (Arms et al. 1974). That species and White Admiral butterflies accounted for all the unusual insect activity noted in the present study. Shiras (1936), the only other author to record insects at wildlife licks, mentioned only two butterfly species. From his descriptions and photograph, those appear to have been Tiger Swallowtails and White Admirals.

Among birds, attraction to Na sources was limited to finches of the subfamily Carduelinae and possibly a few Cedar Waxwings. The many species of warblers, thrushes, flycatchers, and other groups in the area showed no evidence of attraction to Na. Similarly, previous reports of attraction to Na are largely limited to the cardueline finches (Tordoff 1954; Dawson et al. 1965). Those birds are unusual in feeding, and rearing their young, almost exclusively on vegetable material [seeds of trees] (Newton 1972). The Na-poor vegetarian diet probably accounts for the attraction to Na (Tordoff 1954).

Many herbivorous mammals show evidence of Na-deficiency or an attraction to Na in areas where the element is scarce. Species include Snowshoe Hares (Smith et al. 1978), Woodchucks (Weeks and Kirkpatrick 1978), and some microtine rodents (Aumann and Emlen 1965), as well as the large ungulates. In this study, however, only the ungulates (and Porcupines to a lesser extent) made heavy use of the licks and pools. The difference may be due in part to the greater mobility of the ungulates. For example, Moose will travel long distances to mineral licks (Best et al. 1977). Presumably that would be much less feasible for the smaller mammals.

A more basic factor may be the manner in which the different species typically ingest salt. Evidently, the Moose and White-tailed Deer were willing to consume large amounts of water in order to obtain the dissolved minerals. By contrast, the smaller mammals at the licks (Porcupines and Red Squirrels) appeared to be seeking more concentrated minerals where lick water had evaporated. Also, Snowshoe Hares, Woodchucks and Porcupines were frequently seen licking roadside gravel, perhaps to obtain salt in solid form. The smaller mammals may lack the physiological capability to extract salt from large volumes of water. As the pools and licks mainly provide Na-rich water, with crystalline deposits occurring only incidentally, they may have limited attraction for small mammals.

Acknowledgments

I am grateful to H. Hristienko, C. Wedeles, W. May, L. Walters, and A. Hurly for assistance in the field; to B. A. Campbell and C. Wedeles for assistance and advice in preparing the manuscript; and to Minis-

try of Natural Resources staff at Thunder Bay, Wawa, and Maple for support of the work.

Received 20 October 1983
Accepted 18 September 1984

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Fisher, *Martes pennanti*, Behavior in Proximity to Human Activity

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Johnson, William A., and Arlen W. Todd. 1985. Fisher, *Martes pennanti*, behavior in proximity to human activity. Canadian Field-Naturalist 99(3): 367–369.

Accounts are given of three direct observations of the Fisher (*Martes pennanti*) in the wild. These accounts suggest the Fisher is less sensitive to human disturbance than reported in some of the traditional mammalogical literature.

Key Words: Fisher, *Martes pennanti*, behavior, human disturbance.

There are few published accounts of observations of the Fisher (*Martes pennanti*) in the wild. Some mammalogists have considered mustelids such as the Marten (*Martes americana*) and Fisher to be "secretive" (Banfield 1974: 318) or inherently shy, "almost fanatically retiring" (Soper 1964: 294–299), implying that these species are extremely sensitive to human disturbance. However, Halvorson (1961) attributed the lack of sight records of these species to their general scarcity and occurrence in more remote areas, as well as possible inherent shyness. Two accounts of the Fisher in sanctuaries suggest the animal may not be as shy as believed. Hubbard (1943) described a Fisher in Sequoia National Park seemingly showing unconcern in the near presence of man until the animal apparently caught his scent. Pittaway (1978) recounted two observations of Fishers chasing Snowshoe Hares (*Lepus americanus*) along highways in Algonquin Provincial Park and summarized observations of a Fisher habituated to a window feeder. Wildlife species are typically less shy in sanctuaries however, and there is a paucity of direct observations of Fishers outside such protected areas. This paper describes three observations of Fishers in proximity to human activity, but where Fisher trapping is allowed. There is very little scientific information published on the effects of disturbances on Fisher.

On 25 September 1982 a Fisher was observed in a mixed woods stand which borders on farmland 22 km north of Peace River, Alberta (55°25′N, 117°13′W).

Tree cover is predominantly mature White Spruce (*Picea glauca*), interspersed with aspen (*Populus tremuloides*) and Balsam Poplar (*P. balsamifera*). The stand adjoins an abandoned sawmill; about 25% of the canopy spruce trees were selectively logged 3–4 years previous. Winds were 0–5 km/hour, temperature 8–10°C; the sky was overcast and a very light drizzle was falling intermittently. About 0800 (CDST), one hour after sunrise, one of us (W. A. J.) was sitting along side a small skid trail, about 100 m from a country road which receives moderate use (estimated 5–10 vehicle passages daily). He heard the sound of breaking branches about 200 m distant and approached the site of the disturbance from downwind. The sound of breaking branches was coming from underneath a fallen spruce tree (diameter 25–30 cm) whose trunk was about 0.5–1.0 m above the ground surface. The observer walked to the fallen tree, stopping about 10 m from the sound. After three minutes a very large Fisher, believed to be a male, climbed onto and over the tree trunk to a Red Squirrel (*Tamiasciurus hudsonicus*) midden under the tree. The animal was then out of view for 1–2 minutes until it climbed back up onto the trunk, evidently seeing the observer for the first time. Without pausing, the Fisher approached by bounding slowly along the tree trunk, dodging and jumping several branches to do so. It took 2–3 seconds to cover about 5 m. It stopped about 5 m distant, raised its head, and looked at the observer for 2–3 seconds. The Fisher then turned and bounded slowly back along the trunk to the spot where it had been digging, jumped onto the ground and disappeared from sight. A few seconds later it briefly reappeared about 20 m distant before finally disappearing. The gait during its unhurried departure was a bounding lope.

The second and third observations of Fishers were made by W. A. J. while driving on a winter road from the town of Peace River to the community of Loon Lake, Alberta on 10 March, 1983. Forest cover adjoining the road is predominantly mature mixed woods. The cleared driving surface, at present, is only about 3 m wide; the shallow ditches and remainder of the original 9 m wide right-of-way are overgrown with aspen and Balsam Poplar saplings, willow (*Salix spp.*) alder (*Alnus sp.*), and other shrubs. When the road surface is plowed, snow is pushed into the adjoining cover of saplings and shrubbery. This road is moderately-heavily travelled while the ground is firmly frozen; it passes through the Seal Lake gas field, provides the main access for intensive seismic exploration in the vicinity, and receives additional use by logging trucks. There were three or four main construction camps immediately beside the road and additional well-drilling rig camps in the vicinity (56°10′N, 115°58′W) of this second observation. Although road traffic was lighter that day than earlier in the winter (because spring breakup had started) about three vehicles were met immediately prior to the sighting. The daytime high temperature was +6°C, sky was clear, and winds calm.

About 1700 (CST), two hours before sunset, W. A. J. was travelling about 50 km/hour when he saw two medium-sized mammals move onto the road about 300 m distant and run towards him. The animals were identified as a Fisher in pursuit of a Showshoe Hare. The observer braked the vehicle. The Hare was about 75 m distant and the Fisher was about 15 m behind the Hare when the truck reached a full stop. The Fisher chased the Hare within 20 m of the unmoving vehicle, then stopped and paused for an estimated two seconds before bounding onto the snowbank. It disappeared into the brush on the lefthand side of the road. This Fisher was judged (by its size) to be a male. The Hare ran abreast of the vehicle and stopped on the snowplowed bank on the righthand side of the road about 5 m from the truck. It crouched with its ears laid back, breathing rapidly. After resuming travel, the observer noticed Fisher tracks were plentiful on the plowed snowbanks and across the road surface.

An hour later the observer rounded a sharp bend on a less heavily-travelled segment of the road (vicinity of 56°17′N, 115°29′W) and saw a second, smaller Fisher. This animal, running on top of the snowplow bank toward the observer, was 60 m distant. When about 10 m separated the moving truck and the Fisher, the animal bounded into the brush, and climbed about 4 m up a mature White Spruce located on the right-of-way edge and about 5–7 m distant from the passing truck. The observer stopped and walked back to this site 1–2 minutes later. The Fisher, thought to be a female, had descended the tree and disappeared into the mixed woods forest. Additional Fisher tracks were observed on the road at this location. The observer concluded that Fishers were using the snowplow banks as vantage points to hunt Hares browsing on saplings growing in the right-of-way. This evidently differs from the typical behavior of Fishers hunting Snowshoe Hares in east-central North America, which has been characterized as "zigzag foraging" through preferred Hare habitats (Powell 1982). However, Martin Jalkotzy (personal communication, 22 August 1983) reported that Fisher seem to use vantage points such as fallen logs and small elevated ridges

while foraging for Hares in the Boreal Forest of Alberta.

These observations extend the knowledge of this rarely seen species, and suggest that the Fisher may be less sensitive to human disturbance than commonly thought. Reactions to human disturbances doubtlessly vary with snow conditions and food abundance (Douglas and Strickland 1977: 4) and physical condition of the Fisher (Raine 1982: 432). However, it seems likely that the rarity of Fisher sightings may stem more from relative scarcity and occurrence in unsettled areas, than from inherent shyness. Due to over-trapping which occurred during the last part of the nineteenth century and the early part of the twentieth century (Powell 1982), the Fisher was extremely rare when classical mammalogists such as J. Dewey Soper were in the field during the early-to mid-1900's. However, the harvest of Fisher was carefully regulated in Alberta during 1938–71 and its numbers recovered. It is now relatively abundant (Todd and Giesbrecht 1979). The Fisher population likely was at, or near, a cyclic peak at the time of the observations (1982–83), because Snowshoe Hares in the area probably peaked during 1980–81 (Keith et al. 1984) and Fisher populations are thought to lag about three years behind the hare cycle (Powell 1982: 113).

Fishers evidently avoid recent burns or clearcuts in winter (de Vos 1951; Penner 1976), but occupy second growth and preferentially use habitat edges (Kelly 1977). Palman (1977) reported that Fishers seemed to avoid an interstate highway in Maine, although it was not clear if they were avoiding the physical opening or the traffic disturbance. Likewise, Coulter (1966) reported that Fishers seldom travelled along roads or power line rights-of-way. The intensive Fisher activity which we observed along the winter road may be explicable as exploitation of a relative concentration of Hares in and adjoining the second growth on the right-of-way. Riewe (1980) concluded that Snowshoe Hares avoid relatively open shrubby cover along linear disturbances (seismic lines) unless there is intense intraspecific competition for food, as happens during and immediately following cyclic peaks (Keith and Windberg 1978). Further information is required on responses of Fisher to human disturbances and the influence of Snowshoe Hare abundance on these responses. In any event, the Fisher appears to be less sensitive to human disturbance than is commonly thought.

Acknowledgments

We thank Curtis H. Halvorson for helpful comments on the manuscript.

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Received 21 February 1984
Accepted 24 August 1984

Ohio Buckeye, *Aesculus glabra*, on Walpole Island, Lambton County, Ontario

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We record, for the first time in Canada, possibly native, reproducing, populations of Ohio Buckeye, *Aesculus glabra*. These occur on the north end of Walpole Island.

Key Words: Ohio Buckeye, *Aesculus glabra*, native tree, Walpole Island, Ontario.

The range of the Ohio Buckeye (*Aesculus glabra* Willd.) is west of the Appalachian Mountains from western Pennsylvania and Kentucky through the mid-western states (var. *glabra.*) to eastern Kansas and south to central Texas (var. *arguta* (Buckl.) Robins) (Fowells 1965). At the northern limits of its range, Ohio Buckeye occurs in extreme northwestern Pennsylvania, throughout northern Ohio, and in southern Michigan as far north as Eaton and Oakland Counties. The tree is not considered to be native in Canada (Hosie 1969, Scoggan 1979).

In southern Ontario *Aesculus glabra* has occasionally been planted as an ornamental tree as far north as Thunder Bay and Ottawa, where at the National Arboretum (Central Experimental Farm) mature trees fruit successfully every year. Herbarium records indicate that it has escaped at a number of widely separated sites in southern Ontario (Figure 1). At a site along the Nith River near Ayr (Waterloo Regional Municipality), in the flood plain forest, young trees are growing having originated from trees planted at the top of the river valley (J. D. Ambrose and A. A. Reznicek personal communication). In Ontario climatic conditions matching the minimum values given for the natural range of Ohio Buckeye (Fowells 1965) occur within the 160-day isopleth (Brown, McKay and Chapman 1974) along the Lake St. Clair, Lake Erie, and western Lake Ontario shorelines (Figure 1).

During a trip to Walpole Island (42° 33′N, 82° 29′W) in the St. Clair River delta in September 1981 two mature trees were noted at the north end of the island (DAO 327137). The trees are in an area of scattered residences where a number of coniferous species, alien to the island's flora, have been planted. The local residents responsible for the tree-planting assured us that the two Ohio Buckeyes were part of the original forest. Further investigations in May 1982 revealed many trees growing throughout a large area of natural forest and adjacent roadsides in north central Walpole Island (DAO 329838, 329854). In the northeast corner of the main colony it is a major component of the forest canopy with Red Maple (*Acer rubrum*), Cottonwood (*Populus deltoides*), Swamp White Oak (*Quercus bicolor*), Pin Oak (*Q. palustris*) and Red Oak (*Q. rubra*). The largest tree seen in 1982 had a girth measuring 242 cm at breast height. The age of this tree was estimated at 85 years from the core taken by an increment borer in May 1982. All mature trees flower and fruit prolifically every year and seedling growth is abundant and vigorous wherever large trees occur. The presence of many large trees, widely distributed in an area of natural woodland would seem to indicate that the species has been long established on the island and is probably native.

This population is about 60 km east of a disjunct population in Oakland County, Michigan and about 80 km northeast of the most northerly populations within the continuous range in southern Michigan (Figure 1). Although Ohio Buckeye could have been planted by the few white settlers that lived on the island prior to 1839 (Abraham 1924), this seems unlikely as the Horse Chestnut (*Aesculus hippocastanum* L.) was the tree of choice of early planters and gardeners in the northwestern Kent County and western Lambton County area. It is unlikely to have been planted by farmers as Ohio Buckeye is usually considered poisonous to livestock (Fowells 1965).

Three distinct branches of the Algonquin Indian Nation (Ottawa, Chippewa, and Pottawattamie) claim to have traditionally used the St. Clair River delta area for seasonal hunting, fishing and trapping on their yearly migrations (D. M. Jacobs, Land claims research paper. Walpole Island Indian Reserve. Report submitted to the Association of Iroquois and Allied Indians. 184 pp.). The Ottawa and Pottawattamie branches migrated through areas in Ohio and Michigan where present day, native populations of Ohio Buckeye occur. During the war of 1812

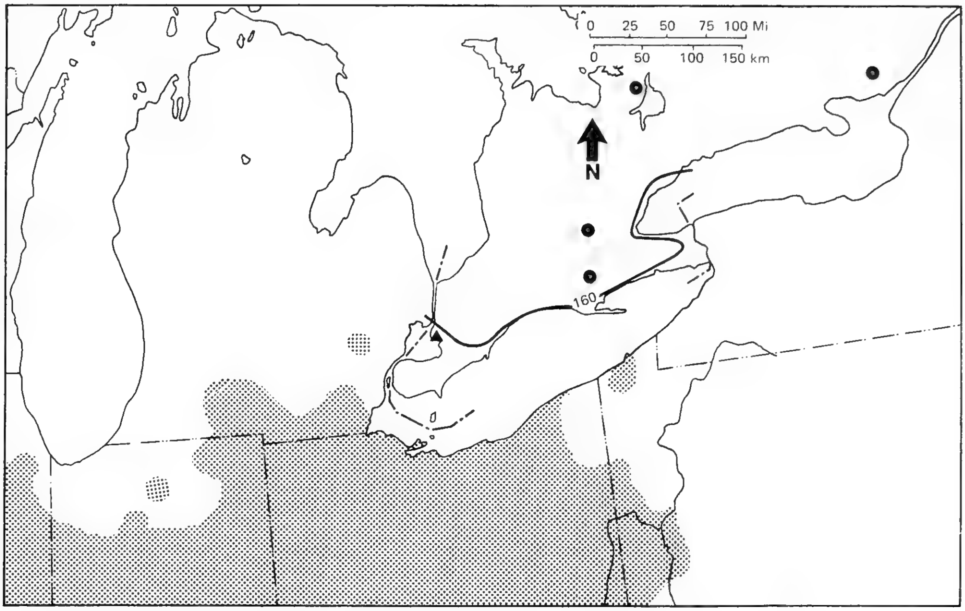

FIGURE 1. A map of southern Ontario indicating sites of escape of *Aesculus glabra* as documented by herbarium specimens (solid circles), the site of the possible native colony on Walpole Island (solid triangle), and the 160 day isopleth identified by Brown et al. (1974).

Walpole Island was established as an open reserve for any homeless, wandering Indians (Abraham 1924). Although it was settled mainly by Indians of the three Algonquin branches who fought on the side of the British Monarchy during the war, Walpole Island was at least a temporary home for many other loyalist Indians fleeing from the United States (Abraham 1924).

The medicinal use of *Aesculus glabra* and other members of the genus *Aesculus* by North American Indians has been reported by some authors (Taylor 1940; Fernald, Kingsley, and Rollins 1958; Tantaquidgeon 1972). Other ethnobotanical uses have also been reported (Millspaugh 1887; Fernald et al. 1958; Barnes and Wagner 1981). Local residents interviewed were unaware of any present day use. Ohio Buckeye may well have been planted on the island by humans in prehistoric or historic times but it seems equally possible that this is a natural, disjunct population. It is probably impossible to determine at this time whether the Ohio Buckeye is a native element of Walpole Island, or whether it has been introduced by man. It is, however, well established in native tree communities and should be considered as part of the Canadian flora. Because Horse Chestnut is increasingly found in native woodlots, the following key is provided to assist in distinguishing the two species in any season.

Key to *Aesculus glabra* and *A. hippocastanum*

1a Bark broken into thick plates; terminal buds less than 2 cm in length, scales glaucous; leaflets usually 5, usually less than 12 cm long, broadly lanceolate, attenuate apically, serrate, abaxially pubescent to glabrous, and with conspicuous tufts of hairs in vein axils; petals 4, yellow with a claw equalling or exceeding the calyx; fruit 3 to 4 cm in diameter .... *A. glabra*

1b Bark broken into thin plates; terminal buds 2 cm or more in length, scales conspicuously resinous; leaflets usually 7 to 9, usually more than 12 cm long, oblanceolate, abruptly acute apically, biserrate, abaxially glabrous, and without tufts of hairs in vein axils; petals usually 5, rarely 4, white with red spots, with a claw shorter than the calyx; fruit about 5 cm in diameter .... *A. hippocastanum*

Acknowledgments

The authors would like to thank A. A. Reznicek (University of Michigan), J. D. Ambrose (University of Guelph) and G. M. Day (National Museum of Man, National Museums of Canada) for their assistance.

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Received 11 January 1984
Accepted 31 July 1984

Common Raven, *Corvus corax*, Robs American Crow, *Corvus brachyrhynchos*, in Aerial Chase

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Kilham, Lawrence. 1985. Common Raven, *Corvus corax*, robs American Crow, *Corvus brachyrhynchos*, in aerial chase. Canadian Field-Naturalist 99(3): 372.

A Common Raven, *Corvus corax*, pursued, but did not overtake, an American Crow, *Corvus brachyrhynchos*, carrying a piece of carrion. The crow dropped the carrion, the raven retrieved it in the air following a steep dive.

Key Words: Common Raven, *Corvus corax*, American Crow, *Corvus brachyrhynchos*, kleptoparasitism.

In the fall of 1980 both American Crows and Common Ravens were coming to feed on the carcass of a cow in a pine wood in Lyme, New Hampshire. On 10 October I saw a crow fly above the treetops with what I supposed was a piece of carrion 2–3 cm in diameter. A raven pursued it, the distance between the two birds remaining about 8 m as though neither bird could gain on the other. The crow dropped the carrion at an altitude of possibly 70 m. The raven closed its wings immediately and retrieved the item in a spectacular dive.

In their extensive summary of kleptoparasitism in birds, Brockman and Barnard (1979) gave no reference to ravens robbing crows, nor to American Crows being robbed by any other bird. I have, however, (Kilham 1982), observed Red-shouldered Hawks (*Buteo lineatus*) robbing crows. Jollie (1976) stated that ravens seldom attack crows which can outclimb and outmanoeuvre the larger bird, a finding not supported in present observations. The agility of ravens in the air is brought out by Bent (1946). Much needs to be learned about the interrelations of crows and ravens.

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Received 27 August 1983
Accepted 1 October 1984

Scurvygrass, *Cochlearia tridactylites*, a New Plant Record for Nova Scotia

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Benjamin, Lawrence K., and Ruth E. Newell. 1985. Scurvygrass, *Cochlearia tridactylites*, a new plant record for Nova Scotia. Canadian Field-Naturalist 99(3): 373–375.

Cochlearia tridactylites, Scurvygrass, is reported from the White Islands of Halifax County, Nova Scotia. This represents a southern range extension of approximately 250 km for the genus and the first report of the genus for Nova Scotia.

Key Words: Scurvygrass, *Cochlearia tridactylites*, range extension, White Islands, Nova Scotia.

On 20 May 1981, *Cochlearia tridactylites* Banks, Scurvygrass, was discovered by the senior author, during an island seabird survey conducted by the Nova Scotia Department of Lands and Forests, on Little White Island. Little White is part of a group of islands known as the White Islands, located about 7 km offshore (44° 53′N, 62° 07′W) from the easternmost part of Halifax County, Nova Scotia. This island is 7.7 hectares in area, has a shore composed of exposed bedrock and a center of humus soil covered by a flora of herbs and low shrubs. Standing dead trees are present on the island. A variety of seabirds nest on Little White including Common Eiders (*Somateria mollissima*), gulls (*Larus* spp.), cormorants (*Phalacrocorax* spp.), Leach's Storm Petrels (*Oceanodroma leucorhoa*) and Black Guillemots (*Cepphus grylle*). *Cochlearia tridactylites* was abundant, forming mats on soil in rock crevices on the shore above the high tide mark. Associated with it were Roseroot (*Sedum rosea*), Seabeach-Sandwort (*Arenaria peploides*), Silverweed (*Potentilla anserina*) and Seaside Crowfoot (*Ranunculus cymbalaria*).

A second discovery of *Cochlearia tridactylites* was made on Big White Island on 3 June 1983. This island is the largest member of the White Islands having an area of 32.4 hectares. It is located approximately 1.2 km southwest of Little White Island. Big White is a wooded island with the trees being predominantly Balsam Fir (*Abies balsamea*) and White Spruce (*Picea glauca*). Breeding seabirds on this larger island include the same species as on Little White except that the Cormorants are absent (P. J. Austin-Smith, Nova Scotia Department of Lands and Forests, Kentville, Nova Scotia, personal communication). On Big White Island as on Little White, *Cochlearia tridactylites* plants were found in clumps in the soil of rock crevices on the shore (Figure 1). Associated plant species were similar to those on Little White. Scurvygrass plants on Big White were found to be most abundant however, on the deep humus soil (> 0.5 m) of the exposed headland at the eastern end of the island (Figure 2). Time limitations prevented a thorough investigation of the entire island so it is unknown if Scurvygrass occurs on another part of Big White aside from the rocky shore and the headland at the east end of the island. On the headland, Scurvygrass was growing with a variety of other plants including Beachgrass (*Ammophila breviligulata*), Dewberry (*Rubus pubescens*), Wild Lily-of-the-Valley (*Maianthemum canadense*), Common Chickweed (*Stellaria media*), Starry False Solomon's Seal (*Smilacina stellata*), Sheep-Sorrel (*Rumex acetosella*), Rush (*Juncus* sp.), Mouse-Ear Chickweed (*Cerastium* sp.), Yarrow (*Achillea millefolium*), Seaside Angelica (*Coelopleurum lucidum*) and stunted White Spruce (*Picea glauca*). Herbarium specimens of *Cochlearia tridactylites* from Big White Island have been deposited in the E.C. Smith Herbarium of Acadia University (ACAD).

To our knowledge, these are the first reports of the genus *Cochlearia* for Nova Scotia. It is not on the list of rare plants for the province (Maher et al. 1978) nor is it on the plant list of the IBP-CT Check Sheet (1974) for Little White Island. The range of *Cochlearia tridactylites* according to Fernald (1950) is in coastal situations from the Labrador Peninsula and the Straits of Belle Isle south to Anticosti Island, Quebec, Newfoundland and the Magdalen Islands. Locations represented by collections in ACAD include Pointe Blanche in St.-Pierre-Miquelon and the following Newfoundland locations: Canada Bay, Funk Island and Ste. Genevieve Bay. The plants on the White Islands represent a southward range extension of approximately 250 km in eastern Canada.

The taxonomy of the genus *Cochlearia* is somewhat unsettled. Several authors (Polunin 1959; Scoggan 1978) have suggested placing all Canadian plants in the single species *C. officinalis* L. because of unclear

FIGURE 1. *Cochlearia tridactylites* Banks in a rock crevice on the shore of Big White Island.

FIGURE 2. Scurvygrass plants were found both in bedrock crevices on the shore (foreground) and on the exposed headland at the eastern end of Big White Island (background).

species distinctions within the genus. Porsild (1973) places eastern Arctic plants in *C. officinalis* L. ssp. *groenlandica* (L.) Porsild. The *Cochlearia* plants found on the White Islands fit Fernald's (1950) description for *C. tridactylites* and until a taxonomic revision is carried out on the genus we prefer to retain this name for this isolated population.

Future investigations of islands in this part of Nova Scotia will likely lead to more discoveries of Scurvy-grass. *Cochlearia* plants on these islands are probably arctic disjuncts, representing relics of a formerly more widespread distribution following the last glaciation, as in the case of *Sedum rosea* (Roland and Smith 1969), a species found growing with *Cochlearia* on the White Islands. The possibility of introduction by birds also exists although Hodgdon and Pike (1969) concluded that long distance dispersal (greater than a few miles) of plant propagules over open ocean to bird islands is not a frequently accomplished phenomenon. Their conclusion was based on a failure to find strong correlation amongst the floras of three bird islands in the Gulf of Maine, plus an absence of potentially adapted species on these islands.

Acknowledgments

The authors would like to express their thanks to the Nova Scotia Department of Lands and Forests, Kentville, Nova Scotia, for providing transport to the White Islands and to Peter Austin-Smith and S. P. Vander Kloet for their critical comments concerning the manuscript.

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Received 16 February 1984
Accepted 2 October 1984

Food and Feeding Behaviour of Subarctic-nesting Merlins, *Falco columbarius*, at Churchill, Manitoba

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Knapton, Richard W., and Cathy A. Sanderson. 1985. Food and feeding behaviour of subarctic-nesting Merlins, *Falco columbarius*, at Churchill, Manitoba. Canadian Field-Naturalist 99(3): 375–377.

Food and feeding behaviour of a pair of Merlins, *Falco calumbarius*, nesting near Churchill, Manitoba, were observed between 2 and 11 July 1983. The female was not observed hunting; all prey items were captured by the male. Prey exchanges occurred 3m to 20m from the nest, and the female fed all parts of the prey to the young. Nestling prey was brought in groups, as if the male had located a nest and took the nestlings individually. Thirty-three prey items were recorded. All were birds, only six were adults, and 17 were identified, of which 15 were Savannah Sparrows, suggesting that the male was hunting over tundra, not in forest.

Key Words: Merlin, *Falco columbaris*, subarctic, Churchill, Manitoba, nestling diet, feeding behaviour.

Food and feeding behaviour of Merlins, *Falco columbarius*, have been reported primarily for pairs nesting in open forest (Lawrence 1949), aspen parkland (Oliphant 1974) and prairies (Hodson 1975) in North America, and in conifer plantations and moorland habitat in Europe (Watson 1979; Newton 1979). In this note, we report on food and feeding behaviour of a pair of Merlins nesting at the edge of the subarctic tundra near Churchill, Manitoba.

The nest was found in mid-June 1983 in a 8m White

Spruce (*Picea glauca*) about 4.5km southeast of Churchill. The nest, about 45cm across by 20cm deep, was probably an abandoned Common Crow (*Corvus brachyrhynchos*) nest, and was located 6m up on the northeast side of the tree. Observations were recorded from 2 July to 11 July from a 6m tower blind erected close to the nest tree, with the blind openings 3m from the nest. A total of 25h 55 min was spent in the blind, of which 12h 25 min was spent on 6 July in an attempt to record all prey items brought to the nest. The identity, condition (e.g. with or without head) and time of delivery of each prey item were recorded.

The first eggs hatched on 28 June (J. Richards, personal communication). The nest contained five chicks on 2 July; therefore, the chicks probably ranged from two to four days of age, assuming that the eggs hatched over a three-day period (Newton 1979), when observations started. The female left the vicinity of the nest only during prey exchanges. While at the nest, she either brooded the young (e.g. for 150 min of a 170 min observation period on 2 July), or perched within 3m of the nest, especially as the young matured (e.g. for 120 min of a 180 min observation period on 11 July), or she prepared prey for the nestlings. She was not observed hunting; all prey items were captured by the male. Observed prey exchanges occurred 3m to 20m from the nest and had the following pattern: the male landed in a spruce and called; the female called back, left the nest, collected the prey item, brought it to the nest after a few minutes, tore it into small pieces, and fed the young all parts of the prey, including wings, legs and feet. With very small prey items, she returned immediately to the nest, whereas with larger items she disappeared for up to five minutes, then appeared at the nest with the prey items partially plucked and headless (see below).

Thirty-three prey items were recorded; all were birds. Six prey items were adults: four Savannah Sparrows (*Passerculus sandwichensis*), a dark-gray plumaged passerine, probably Dark-eyed Junco (*Junco hyemalis*) and a Lesser Yellowlegs (*Tringa flavipes*). Two prey items were small "downy" young, probably of a shorebird. The remaining 25 items were passerine nestlings or fledglings, at various stages of development. Ten had extensive areas of unfeathered skin and were very young nestlings or had been extensively plucked; only one was headless. The remaining 15 were young birds with partially-developed primaries; eight of those were headless. Eleven of the 25 were identified as young Savannah Sparrows. The remaining 14 were not positively identified but six also resembled Savannah Sparrows. Thus, of 17 prey items identified (six adults, 11 nestlings), 15 were Savannah Sparrows.

Young birds were often brought in groups. For example, on 4 July, six prey items were brought to the nest during a two-hour watch; three very small nestlings of similar size and development were brought during an 11-minute period, and those were followed by three other nestlings of larger size and more advanced development brought in during an 8-minute period. This suggests that the male had located two nests and had robbed each of its young in turn. Similar "runs" of nestlings as prey occurred on four other occasions.

When the female alighted at the rim of the nest with prey, usually the young birds turned toward her and she fed the nearest one. If they did not respond to her arrival, she uttered two to three soft clucks until one or more young responded by turning to her and being fed. All parts of the prey were eaten, except for the legs of the adult yellowlegs. The female took the legs away, but a yellowlegs' leg was at the nest the next day; possibly the remains had been cached (see Oliphant and Thompson 1976) and retrieved during the intervening period. The leg was not consumed during subsequent observation periods, and it may have been cached in the nest itself.

The position of the blind precluded many opportunities to observe where the male hunted. Observations of the male leaving the nest area indicated that he flew north, east or west, toward open tundra, and not south into coniferous forest. The fact that the major prey were Savannah Sparrows, a tundra-nesting passerine, suggested that he was hunting primarily over tundra. In that respect, the Merlins at Churchill resembled those in northern Europe that nest in young conifer plantations but continue to hunt over moorland, rather than the Merlins that nest in forest and take forest species (Lawrence 1949) or suburban species (Oliphant 1974).

Acknowledgments

We thank Jim Richards and Bruno Kern for the location of the nest, and Ted Cross and Bruno Kern for use of the blind. We also thank Tony Erskine for helpful comments on the manuscript.

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Received 16 February 1984
Accepted 19 September 1984

Precocial Breeding in a Southern Ontario Muskrat, *Ondatra zibethicus*, Population

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Proulx, Gilbert, and Bruce M. L. Buckland. 1985. Precocial breeding in a southern Ontario Muskrat, *Ondatra zibethicus*, population. Canadian Field-Naturalist 99(3): 377–378.

The examination of the uteri of 594 juvenile Muskrat (*Ondatra zibethicus*) from Southern Ontario in the fall of their year of birth indicated that three young females had conceived a single litter. This is the first verified evidence of precocial breeding in an Ontario Muskrat population.

Key Words: Muskrat, *Ondatra zibethicus*, Ontario, precocial breeding.

Precocial breeding in Muskrat (*Ondatra zibethicus*) populations has been observed in the United States by Errington (1954) and Sather (1958). In Canada, precocial breeding activities were reported by Stewart and Bider (1974) in Quebec, and Parker and Maxwell (1984) in New Brunswick. In Quebec, however, although these animals were about seven months of age, they had over-wintered and were entering what would have been their first normal breeding season. Such animals are often classified as adults (Parker and Maxwell 1980). In Ontario, despite extensive studies by Wragg (1953), Proulx and Gilbert (1983) and Proulx et al. (1983), no precocial breeders were ever reported.

Carcasses of Muskrat trapped between the end of October and mid-November 1983 in the Ontario Ministry of Natural Resources' Cambridge District were examined for sex, age and productivity. Muskrat were aged by Sather's (1954) dentition method, i.e., in adult dentition, the end of the first fluting of the first upper molar is visible while in juvenile dentition, the fluting runs deep into the alveolar socket and the end of the fluting is not visible. Productivity was determined by placental scar counts.

Uteri examination indicated that three of 594 juvenile females had conceived. Two had been caught in drainage ditches of Puslinch Township, Wellington County. One female had 9 placental scars and the second had 7. The third female was captured at Luther Marsh, West Luther Township, Wellington County, and had 7 placental scars.

The mean litter size of these early breeders was 7.7, slightly more than the 6.3 and 6.1 mean litter sizes for female adults reported by Proulx and Gilbert (1983) and Proulx et al. (1983), respectively. This mean is similar to the 7.5 mean litter size of precocial breeders reported by Parker and Maxwell (1984).

It appears that, with a mild winter such as was observed in 1982-83 (Farmer 1983a,b), some females succeed in rearing their first litter early enough in the breeding season so that offspring can reproduce during their own season of birth. However, the lack of evidence of precocial breeders in previous studies and the small proportion of such precocial breeders in our sample suggest that precocial breeding does not occur frequently in Southern Ontario. These specimens are the first documented evidence of precocial breeding in an Ontario Muskrat population.

Acknowledgments

We would like to thank Nancy L. Tilt, Ontario Ministry of Natural Resources, Cambridge District, who revised the original manuscript. Our thanks to the two referees for their useful comments.

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Received 7 February 1984
Accepted 10 September 1984

Observations of Intraspecific Behavior of Meadow Jumping Mice, *Zapus hudsonius*, and Escape Behavior of a Western Jumping Mouse, *Zapus princeps*, in the Wild

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Jones, Gwilym S., and Diana B. Jones. 1985. Observations of intraspecific behavior of Meadow Jumping Mice, *Zapus hudsonius*, and escape behavior of a Western Jumping Mouse, *Zapus princeps*, in the wild. Canadian Field-Naturalist 99(3): 378–380.

In Colorado, Meadow Jumping Mice (*Zapus hudsonius*) were observed in a jumping, squeaking behavior which has only been reported once previously and, in British Columbia, a Western Jumping Mouse (*Zapus princeps*) was observed crawling which has not previously been reported for that species.

Key Words: Meadow Jumping Mouse, *Zapus hudsonius*, Colorado, intraspecific behavior, Western Jumping Mouse, *Zapus princeps*, British Columbia, escape behavior.

Observations of jumping mice (*Zapus*) behavior in the wild, free of the stress of captivity, are relatively uncommon. Thus, even incidental observations are critical to the development of knowledge of their behavior.

At 1730 on 21 June 1972 near Woodburn, El Paso County, Colorado, we were attracted by what seemed to be highly agitated squeaks of small birds. Upon our approach, we observed several Meadow Jumping Mice (*Zapus hudsonius*) jumping into the air and squeaking, in close proximity to one another (i.e. less than one foot). This activity was centered around a solitary, low shrub on the edge of a wet depression which was dominated by a lush growth of sedges, grasses, and mints; the surrounding, higher ground was dominated by sagebrush with sparse grasses and scattered pines. The jumps (i.e. bounds) of the mice were about 60 cm long and 45 cm above the ground. Upon our close approach, the mice disappeared, apparently into several holes in the ground at the base of the shrub. Three hundred and fifty snap-back traps were set in the depression and surrounding sagebrush, including the area near the shrub; four Meadow Jumping Mice, four Meadow Voles (*Microtus pennsylvanicus*) and two Vagrant Shrews (*Sorex vagrans*) were collected. All of the Meadow Jumping Mice were caught at the base of the shrub.

The only other report of this behavior was a second-hand report by DeKay (1842) — "Mr. Jesse Owen . . . writes to me . . . 'I once saw two of them . . . between sunset and dark, jumping up in rapid succession and making a chirping noise like sparrows'." Our observation confirms this behavior and adds details concerning the magnitude of the jumps. Dagg (1973) con-

cluded that jumping mice walk and bound. What we observed were certainly bounds, but they were part of an intraspecific behavior which did not have the purpose of moving from one location to another. The jumps were about two-thirds the length of the initial escape jumps described by Quimby (1951) and Whitaker (1963).

Edwards (1955) and Sheldon (1934) reported squeaking by adults of this species, but not in association with intraspecific behavior such as that reported here. Svihla and Svihla (1933), on the other hand, reported that Western Jumping Mice (*Zapus princeps*) in the Pacific Northwest squeak when fighting. Although Sheldon (1934) reported that individuals of *Z. hudsonius* do fight, Whitaker (1972) concluded that they are ". . . generally not antagonistic towards one another." We can only report that the mice in Colorado were jumping and squeaking in very close proximity to one another. The fact that we observed and then caught the four mice within a couple of feet of each other, suggests a gregarious unit which was much more closely associated than that inferred by Sheldon (1934). The jumping-squeaking behavior described above is rarely observed. None of the following, intensive studies reported such behavior: Sheldon (1934); Hamilton (1935); Quimby (1951); Whitaker (1963).

The mice discussed above apparently used holes to escape our approach, but, as noted by Maser et al. (1981) and experienced by most who have pursued fleeing jumping mice, they occasionally perform a "vanishing act". Observations of an individual *Zapus princeps* sheds some light on this "mystery". During mid-afternoon of 25 July 1972, while setting traps for this species in a small field about 15 miles east of Chilliwack, British Columbia, we gave chase to a jumping mouse whose movements had caught our attention. The field was predominately vegetated with a procumbent *Rubus* sp, grasses, and mixed herbs surrounded by brush which in turn was bounded by a swampy area with skunk cabbage except for the north side which was bordered by the Fraser River. The entire chase took place in the field. The mouse's jumps were between 45 and 60 cm long. After several jumps, it sat for a few seconds, then crawled under the vegetation for about 25 cm and then jumped again. After several such sequences, the mouse jumped in our direction and was caught by hand. Examination revealed that the mouse was in good condition (i.e. no broken leg or other debilitating factor was apparent).

Although such crawling behavior has been reported for *Zapus hudsonius* (Quimby 1951; Whitaker 1963), it has apparently not been for *Z. princeps*. We submit that, if we had been in thick vegetation rather than in a relatively open field, the mouse may well have been able to creep away undetected. Thus, rather than bounding, sitting, and then bounding again as reported by Grinnell and Storer (1924) and Taylor and Shaw (1927), *Zapus princeps* can escape through vegetation by utilizing a crawling behavior in combination with the bound and sit. In support of this contention, we observed another mouse, which was live-trapped in the same field, escape in a campground where there was no ground cover at all. It employed typical bounds, approximately 60 cm long and 30 cm high, when pursued for about 30 m. Although somewhat erratic in direction, the mouse fled to the nearest available cover, a wooded area with ground cover. Obviously, the crawling behavior would have been detrimental in this habitat. The length of the jumps of this individual in sustained flight were consistent with observations by Grinnell and Storer (1924), but considerably shorter than the maximum lengths reported by Hollister (1912) and Taylor and Shaw (1927).

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Received 26 January 1984
Accepted 29 November 1984

Cystopteris protrusa, Creeping Fragile Fern, an Addition to the Flora of Canada

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Britton, D. M., W. G. Stewart, and W. J. Cody. 1985. *Cystopteris protrusa*, Creeping Fragile Fern, an addition to the flora of Canada. Canadian Field-Naturalist 99(3): 380–382.

Cystopteris protrusa is reported as new to the flora of Canada from three localities in southern Ontario: one in Elgin county and two in Essex County. Cytological vouchers for *C. protrusa* and *C. fragilis* var. *mackayi* are cited.

Key Words: *Cystopteris protrusa, C. fragilis* var. *mackayi*, Canada, Ontario, cytology.

The fern species *Cystopteris protrusa* (Weath.) Blasdell is probably not well known to most Canadian botanists. Many are content to relegate all Common Fragile Ferns in Canada to *Cystopteris fragilis* (L.) Bernh., even though Blasdell (1963) monographed the genus and showed that there was a sexual diploid segregate entity with a distinctive morphology within the collective species *C. fragilis*. This species, *C. protrusa*, is common and abundant in the southeastern United States (Mickel 1979) and occurs as far north as Illinois, Minnesota and Wisconsin (Peck 1982). The species is well described and documented for southern Michigan by Wagner and Hagenah (1956). Key features to distinguish this species from *C. fragilis* var. *mackayi* Lawson are the green to light yellow stripes of mature plants, the petiolules on the basal pinnae and the heavy felted (hairy not scaly) rhizome with its apex extended beyond the stipe bases (hence *protrusa*) (Figure 1). For definitive identification, one should check for small spores and diploid (n = 42) chromosome number.

It should be noted that Lellinger (1981) considers that *C. fragilis* var. *mackayi* Lawson should be called *C. tenuis* (Michx.) Desv. if it is a derived allotetraploid. Haufler (personal communication) considers that evidence from isozyme studies supports the view that this taxon is an allotetraploid.

This fern was first discovered in Canada by W. G. S. in Elgin County approximately 2 km west of the City of St. Thomas on river valley land along Dodd's Creek.

The plants first came to his attention early in 1979 during construction of a portion of the Elgin Hiking Trail. At that time the colony was assumed to be the more common *C. fragilis* var. *mackayi* even though the general ecological conditions and the unusually large number of fronds impressed him as being atypical for that taxon. When early in 1981 he was alerted by the senior author to the possibility of the occurrence of *C. protrusa* in his area, this colony immediately came to mind and on April 26, 1981 a specimen (*Stewart 2969*) was collected for determination.

The site is located in open deciduous woodland at the base of a north facing hillside along a narrow flat area formed at the second flood plain level of Dodd's Creek. The soil at this level is composed of black humic silt, to a depth of at least 16 cm and shows little evidence of recent disturbance.

Forest succession on the second level is evidenced by numerous dead and aged specimens of Hawthorn (*Crataegus*) of at least two species, which have now been overtopped and shaded out by the existing canopy species. This present young forest is approximately 10 m in height and consists primarily of Sugar Maple (*Acer saccharum*) with two species of Ash (*Fraxinus* spp.), Black Walnut (*Juglans nigra*), Black Cherry (*Prunus serotina*), Pignut Hickory (*Carya cordiformis*) and Ironwood (*Ostrya virginiana*)

FIGURE 1. *Cystopteris protrusa* from 2 km west of St. Thomas (*Stewart 2975* DAO).

occurring in that order of abundance. The understory is quite open and consists of a sparse growth of maple seedlings interspersed with a few shrubs of Tartarian Honeysuckle (*Lonicera tatarica*). In the areas occupied by *Crataegus*, Grape (*Vitis* spp.) has overtopped many of that species.

Vascular plant associates of *Cystopteris protrusa* on the second flood plain level include Sedge (*Carex* sp.), *Isopyrum biternatum*, Violet (*Viola soraria*), Speedwell (*Veronica* sp.), Running Strawberrybush (*Euonymus obovatus*), Wild Columbine (*Aquilegia canadensis*), Thimbleweed (*Anemone virginiana*), Cow-parsnip (*Heracleum lanatum*), Virginia Cowslip (*Mertensia virginica*), Avens (*Geum* sp.), Agrimony (*Agrimonia gyrosepala*), Harbinger-of-spring (*Erigenia bulbosa*), Mayapple (*Podophyllum peltatum*) and Pepperroot (*Dentaria laciniata*).

No other species of ferns occur on the second flood plain level in the vicinity of *C. protrusa*.

Several genera of mosses occur on the flood plain, with *Fissidens* and *Climacium* in the immediate vicinity of *C. protrusa* and the rare moss, *Bryoandersonia*, occurring in abundance on the north facing hillside.

The known collections of *Cystopteris protrusa* (Weath.) Blasdell from Canada are:

ONTARIO: Elgin County: 2 km. west of St. Thomas along Dodd's Creek, *Stewart 2969* (OAC), *2975* (DAO, OAC), *Britton 8370* (OAC), *Cody 29851* (DAO); Essex Co.: Anderdon Twp. Conc. IV, lot 13, 3.0 mi. n.e. of Splitlog, River Canard, cytologically determined as $n = 42$ II, *Britton 8329* (OAC); Colchester S. Twp., Conc. II, lot 11, Affleck Bush, no cytology but spores are small in comparison with those of *C. fragilis* var. *mackayi, G. W. Waldron s.n.* 9 August 1983 (OAC).

The cytology of three separate colonies of *Cystopteris protrusa* at the Elgin County location was studied and all proved to be triploid rather than diploid as expected. Morphologically they are typical of *C. protrusa* and so are considered to be autotriploids rather than hybrids with some other species. Most of the spores are abortive, although a few very large and presumably unreduced spores are produced. The latter did germinate in artificial culture medium. The plants are now under study by C. Haufler of the University of Kansas for analysis of isozymes and cytological study.

As early as 4 June 1971 one of us (D. M. B.) considered that the rich Carolinian woods of Rondeau Provincial Park would be an ideal habitat for *Cystopteris protrusa*. Field fixations for cytology were made at that time (*Britton 2329*) from that locality. Another collection was made (*Britton 2330*) from Elgin County, Yarmouth, Conc. II, lot 26. Both were tetraploid ($n = 84$ II) and the plants are referable to *C. fragilis* var. *mackayi* Lawson.

Additional cytological vouchers in OAC referable to this latter taxon from southern Ontario include the following (all were $n = 84$ II):

Elgin Co.: Malahide Twp. Conc. IV, lot 30, *Britton 8372*;

Kent Co.: 1.5 mi north of Clearville, Orford Twp. I, lot 12, *Britton 8369*;

Lincoln Co.: Bank above hwy. on south side just west of Jordan and bridge, *Britton and Lewis 6457*;

Welland Co.: Pt. Abino, northwest corner, *Britton 7835*,

Niagara Glen, talus slope, *Britton 7831, 7832*.

When one compares the detailed notes by W. G. S. on the St. Thomas locality with the associated species at the two stations in Essex County, and with those specified by Wagner and Hagenah (1956) for Michigan, no clear striking similarities are evident. *Podophyllum peltatum* is mentioned three times, *Dentaria laciniata*, Black Cherry, Black Walnut and Hickory twice each; but all these species are sufficiently common to be of little aid in identifying the habitat of *Cystopteris protrusa* in Canada. Instead, we are left with descriptions of sites of open southern woodland (often river-valley land) from which the original forest has been destroyed. The soil is usually a sandy loam and the sites have a light canopy but with a good deal of wind protection. The picture suggests colonization of these sites recently, i.e., within the last fifty years.

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Received 17 January 1984
Accepted 14 September 1984

Hunting Behaviour of Golden Eagles, *Aquila chrysaetos*, Migrating in Southwestern Alberta

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Dekker, Dick. 1985. Hunting behaviour of Golden Eagles, *Aquila chrysaetos*, migrating in southwestern Alberta. Canadian Field-Naturalist 99(3): 383–385.

Golden Eagles (*Aquila chrysaetos*) caught seven Richardson's Ground Squirrels (*Spermophilus richardsonii*) after low flapping flights and eight after low-level, high-speed glides initiated from soaring flight. Surprise was the basic hunting strategy. One eagle stooped at a Coyote (*Canis latrans*), and twice an eagle hung low over Coyotes which stood off and faced the eagle. A Badger (*Taxidea taxus*) apparently ignored a low hovering eagle. On two occasions an eagle hung over a Hereford steer (*Bos taurus*), landed on its back and rode it for about 300 m while the steer ran downhill. An adult Golden Eagle twice pirated ground squirrels from Red-tailed Hawks (*Buteo jamaicensis*).

Key Words: Golden Eagle, *Aquila chrysaetos*, hunting methods, ground squirrels, *Spermophilus richardsonii*, Coyote, *Canis latrans*, Badger, *Taxidae taxus*, cattle, *Bos taurus*, piracy.

Golden Eagles (*Aquila chrysaetos*) are known to prey on ground squirrels (*Spermophilus* spp.) (Godfrey 1966; Brown and Amadon 1968; Olendorff 1976; Boag 1977). How such prey species are captured has not been described in detail. This paper gives information on the hunting techniques used by Golden Eagles foraging for Richardson's Ground Squirrels (*Spermophilus richardsonii*) in southwestern Alberta. The eagles also interacted with Coyotes (*Canis latrans*), a Badger (*Taxidea taxus*) and domestic cattle (*Bos taurus*). These latter observations probably do not represent genuine hunting behaviour of the eagles, but such incidents are rare and therefore noteworthy.

Study Area and Methods

The study area is in grassy foothills west of Cochrane, Alberta, where Golden Eagles are common during March-April and September-October (Dekker 1970). Richardson's Ground Squirrels are locally abundant, emerging from hibernation in early March and remaining active until October. From 1960 to 1981, I spent 98 days birdwatching in the area: 31 in March, 29 in April, 16 in September and 22 in October. Days afield lasted 5-10 h and were spent hiking about or sitting on a prominent hill on which I had constructed a minimum of shelter using a log and some branches. This lookout afforded a wide view of a south-facing range of grass-covered hills rising about 100 m above the flats at their base. Through 10 — 50 binoculars, approaching eagles could be spotted when they were 2-3 km away and I observed them as long as they remained in view. Each day I sighted one or more Golden Eagles and on exceptional days I saw up to about 50 (Dekker 1970). Observations were written down at the end of the day.

Results and Discussion

The basic strategy used by Golden Eagles in hunting ground squirrels was to take them by surprise, but the techniques varied and seemed dependent on weather conditions. During overcast and calm or rainy periods, the eagles often sat on posts, trees or hillsides. Hunting attempts consisted of flapping flights or glides at low levels over areas where squirrels were common. On seven occasions I saw low-flying eagles drop onto the ground and begin eating a squirrel or carry one away. A similar hunt was reported by Dixon (1937).

During sunny and windy weather, many Golden Eagles flew high and soared. Hunting attempts were initiated by flexing the wings and stooping or gliding down at varying angles. Descents covered horizontal distances of up to 2 km and terminated in high-speed glides low over sloping or level ground. I saw eight captures of ground squirrels resulting from this technique. In one case, the eagle seized the prey in one foot and carried it aloft without stopping. In the other cases, the eagle came to a sudden halt and sat for 10–60 sec before it began to feed on a ground squirrel. Some eagles approached areas of prey abundance by a devious route, apparently to maximize surprise. For instance, many soaring eagles descended downwind from a hill opposite my lookout, then changed direction to come upwind, pass low over the crest and begin a fast glide down and across slopes where ground squirrels were numerous. At an estimated 1–3 m high, the eagles followed the contour of the terrain. Attempts to seize prey were probably made in an opportunistic way and were not aimed at specific squirrels seen from afar but only at those encountered by chance along the eagle's route. After an unsuccessful hunt across a hillside, the eagle pulled up steeply

into the wind and either resumed soaring or descended again to make a pass along the slope in the opposite direction and lower on the hillside than before. On 12 occasions I glimpsed a ground squirrel darting away just ahead of and below the gliding eagle, which made a sudden movement of the wings, as if to intercept the prey, which escaped. Probably many unsuccessful attempts by these low-flying eagles to seize ground squirrels were not visible to me. Therefore I have not attempted to determine hunting success rates.

Some soaring eagles descended from a high altitude, presumably to attack ground squirrels, in a near vertical stoop at tremendous velocity to just above the ground where the bird braked and pulled up. All six of these vertical hunts were unsuccessful. Such tactics are probably more effective on prey species that do not retreat into burrows.

In the study area I never saw White-tailed Jack Rabbits (*Lepus townsendii*) nor any other small- or medium-sized mammals except ground squirrels that could be considered suitable prey for Golden Eagles. Frequently observed were Coyotes and Badgers. On three occasions, I saw Golden Eagles interact with Coyotes. An adult eagle flying at abouty 50 m altitude made a single stoop at a Coyote trotting along a steep draw, about 1.5 km from my observation point. As if hit, the Coyote fell several meters down the slope, recovered and ran away. On two occasions, both occurring in late October, an immature Golden Eagle hung against a strong wind over a Coyote, which stood and faced the bird. In one case, the eagle was 6–10 m high and flew away after about one minute. In the other case, the eagle dropped to 2–4 m and stayed about 10 minutes. Twice the Coyote raised itself on its hind legs or jumped up as if to bite the eagle, which rose slightly and lowered itself again as soon as the Coyote dropped on all-fours. Several times the Coyote took a few steps backwards or sideways and once it turned as if to walk away. When the eagle dropped lower with extended feet as if to seize the Coyote from behind, the Coyote quickly resumed a position facing the eagle, which rose again. Eventually, the eagle flew away. One immature Golden Eagle hovered 2–3 m above a Badger which halted and faced the bird for about half a minute, then walked away with the eagle sailing above it for a short distance.

Similar observations of Golden Eagles confronting Wolves (*Canis lupus*) and Red Foxes (*Vulpes vulpes*) were reported by Murie (1961) from Alaska. In Manitoba, Hatch (1968) observed a Red Fox stand off an immature Golden Eagle until an adult Golden Eagle attacked the fox from behind and eventually killed it. Successful attacks by Golden Eagles on wild ungulates have been occasionally reported (Bent 1937). Bruns (1970) saw an eagle descend onto the back of a Pronghorn (*Antilocapra americana*) which was brought down and killed.

On 18 March 1961, at Morley, Alberta, I observed an immature Golden Eagle descend against a strong wind until it hung about 1 m above the back of a full-grown Hereford steer grazing on an open hillside. The steer looked up, began walking down the 20–30° slope and broke into a run when the eagle landed on the steer's back and hung on with spread wings. At the base of the hill some 300 m down, the eagle lifted off. It soared over the hill for several minutes and then descended to another steer and repeated the same activity with similar results. During the ride, the eagle held its wings extended, occasionally beating against the flanks of the steer, and once it momentarily lifted off about 0.5 m. Eventually, it sailed away.

The eagles often attempted to steal ground squirrels from each other. Some eagles lost their prey to conspecifics; others ate their catch seemingly unperturbed by the arrival of one to three other Golden Eagles or immature Bald Eagles (*Haliaeetus leucocephalus*) that landed nearby. I observed two incidents of interspecific piracy involving Red-tailed Hawks (*Buteo jamaicensis*). In one case, an adult Golden Eagle pursued a flying Red-tail which was carrying a ground squirrel in its feet; the hawk dropped the squirrel just before being overtaken, and the eagle landed on the prey. In the second case, an adult eagle approached a Red-tail in the grass. The hawk flew off, and on the exact spot where it had stood, the eagle landed and began to feed on a ground squirrel.

Acknowledgments

Wayne Nelson read an earlier version of the manuscript, made helpful comments and supplied relevant literature. David Ealey read the final version.

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Received 20 June 1984
Accepted 24 August 1984

First Record of an Albino Wild Columbine, *Aquilegia canadensis*, for Ontario

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Hodgins, James L. 1985. First record of an albino Wild Columbine, *Aquilegia canadensis*, for Ontario. Canadian Field-Naturalist 99(3): 385.

The albino form of Wild Columbine, *Aquilegia canadensis* L., considered by Gray to be "very rare", is recorded from Ontario for the first time.

Key words: *Aquilegia canadensis*, Wild Columbine, albino, Ontario, new record.

The white-flowered form of *Aquilegia canadensis* L. was first described by (House 1923) and given the name forma *albiflora* House. According to Fernald (1950) this albino is "very rare" in eastern North America where the red-orange form is typical for this species. I report here the first documented sighting for Ontario and possibly Canada.

The albino specimen was observed on 3 June 1983 at the Greenwood Conservation Area in Durham Regional Municipality, Ontario by J. L. H. and Z. Zichmanis. It was growing at the base of a west-facing valley slope. The slope was covered with mixed deciduous forest. The albino was at the margin of forest and floodplain on the east side of Duffin Creek (43° 54′N, 79° 03′W). The perianths of the flowers were pure white; the vegetative portions appeared typical. Very few species normally having petals and / or sepals in the scarlet to yellow range ever have white-flowered forms, as contrasted with those in the Cardinal flower red to blue range. (J. S. Pringle, Royal Botanical Gardens, Hamilton, Ontario, personal communication).

Three colour photographs of the specimen in situ were examined and the species and form verified by J. S. Pringle (HAM). These photographs have been deposited at the herbarium of the Royal Ontario Museum, cat. #TRT 232462. Four weeks after flowering, samples of the abundant seed were taken from this plant.

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Received 19 January 1984
Accepted 17 September 1984

Occurrence of the nematode *Protospirura muris* in Alaskan Northern Red-backed Voles, *Clethrionomys rutilus*

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Bangs, Edward E. 1985. Occurrence of the nematode *Protospirura muris* in Alaskan Northern Red-backed Voles, *Clethrionomys rutilus*. Canadian Field-Naturalist 99(3): 386–388.

Examination of 1597 voles, captured on the Kenai National Wildlife Refuge, Alaska from 1977–1983, documented 19 cases of *Protospirura muris* infection. Adult and male Northern Red-backed Voles (*Clethrionomys rutilus*) from Black Spruce (*Picea mariana*) habitats were the primary host of *P. muris*.

Key Words: *Protospirura muris*, Northern Red-backed Vole, *Clethrionomys rutilus*, parasite, nematode.

The helminth parasite *Protospirura muris* [= *Mastophorus muris* (Gmelin 1790)], has a holarctic distribution and has been documented in various rodent hosts. *P. muris* has been reported in Japanese wild rats, *Rattus* spp., (Uga et al. 1981), field mice *Apodemus speciosus* and *A. argenteus*, in the Koshiku Islands of Japan (Yagi and Kamiya 1981), field voles, *Microtus arvalis*, in Romania (Chiriac and Tuta 1977) and East Germany (Krauss 1977), various small mammals in the USSR (Petrov and Kvitko 1977), Northern Red-backed Voles, *Clethrionomys rutilus*, in northern Alaska (Rausch 1952), Meadow Voles, *Microtus pennsylvanicus*, in Michigan (Rausch and Tiner 1949), and Cotton Rats, *Sigmodon hispidus*, in Virginia (Seidenberg et al. 1974).

The parasite cycle involves insects as intermediate hosts and larvae were found experimentally to develop in insects of the orders of Orthoptera, Dermaptera and Dictyoptera (Quentin 1970). Fleas are the most likely natural intermediate host (Beaucournu and Chabaud 1963). Rausch and Tiner (1949) reported that *P. muris* was not a general parasite of North American and vole infections were localized. The occurrence and host preference of *P. muris* is poorly documented in North America.

Study Site and Methods

Fifteen hundred and ninety-seven voles were captured with snap traps on the Kenai National Wildlife Refuge in southcentral Alaska (60° N, 150° W), during the summers of 1977 through 1983. Trapping was conducted in various boreal forest successional stages to determine the effects of mechanical disturbance of habitat on small mammal communities (Bangs 1979), and to monitor small mammal abundance. Small mammals were captured in both recently disturbed (since 1975) and mature undisturbed 100-year-old Paper Birch (*Betula papyrifera*)-White Spruce (*Picea glauca*) stands, 30-year-old Paper Birch-White Spruce stands, and 30-year-old Black Spruce (*Picea mariana*) stands. Most trapping occurred at Willow Lake, the Moose Research Center, and Mystery Creek (Figure 1). At Willow Lake and the Moose Research Center disturbed and undisturbed stands of all three habitat types sampled were adjacent to, or within, three kilometers of one another. The Mystery Creek area contained only recently disturbed and undisturbed 30-year-old Black Spruce stands. A detailed description of vegetation in these areas was presented by Bangs (1979). Other habitats on the refuge were rarely sampled for small mammals.

All captured voles were frozen, then later the stomachs visually examined for the occurrence of *Protospirura muris*.

Results and Discussion

Northern Red-backed Voles (NR Voles) comprised 97% of all voles captured (Table 1) and were the only species infected with *Protospirura muris*. This was probably due to the low numbers of other species examined rather than to the host-specificity of *P. muris*. The occurrence of *P. muris* was low, slightly over one percent and similar to the two percent occurrence of *P. muris* in Meadow Voles in Michigan (Rausch and Tiner 1942). Most *P. muris* were located in the lower stomach at its junction with the small intestine.

P. muris were primarily found in NR Voles captured in Black Spruce stands. Fourteen of nineteen (74%) infections of *P. muris* came from NR Voles captured in Black Spruce stands while only 25% of all NR Voles examined were caught in Black Spruce stands. Rausch (1942) also reported that *P. muris* were restricted to voles inhabiting spruce stands. The prevalence of *P. muris* in NR Voles was significantly (x^2 = 16.4, p $>$ 0.05) related to Black Spruce habitats compared to other forested habitat types. There were no significant differences in *P. muris* infection rates detected in recently disturbed

TABLE 1. The abundance and habitat preference of 1552 Northern Red-back Voles captured on the Kenai National Wildlife Refuge from 1977–83. Numbers of Northern Red-backed Voles infected with *Protospirura muris* are in parenthenseses.

	1977[a]	1978[b]	1979	1980	1981[c]	1982	1983	Total
Mature Forest	153	247(3)	68	78	211	23	37(1)	817(4)
30-yr-old Birch-Spruce	86	159	45	0	18	0	0	308(0)
30-yr-old Black Spruce	32(5)	303(7)	43(1)	0	16(1)	0	0	394(14)
Other	0	0	156(1)	0	33(1)	0	0	33(1)
TOTAL	271(5)	709(10)	156(1)	78(0)	278(2)	23(0)	37(1)	1552(19)

[a]31 Meadow Voles (*Microtus pennsylvanicus*) and 3 Bog Lemmings (*Synaptomys borealis*) were also captured.
[b]5 Meadow Voles were also captured.
[c]1 Meadow Vole, 1 Bog Lemming, and 4 *Microtus* spp. also were captured.

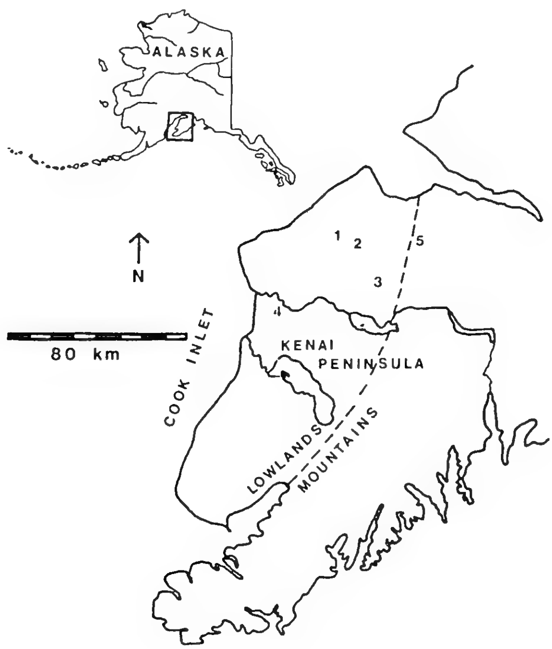

FIGURE 1. Capture locations of Northern Red-backed Voles infected with *Protospirura muris* on the Kenai Peninsula, Alaska. Location 1 – represents Willow Lake; 2 – Moose Research Center; 3 – Mystery Creek; 4 – Soldotna; 5 – Alpine meadow.

and undisturbed areas in the same habitat type. This indicates that the prevalence of *P. muris* was related to factors other than canopy cover. The one infected NR Vole captured outside of the forested habitat was caught in a wet alpine meadow which suggests that the presence of *P. muris* may be related to relatively high soil moisture content. Since NR Voles were common in all habitats, the apparently limited distribution of *P. muris* was probably more dependent on the occurrence of a specific intermediate host than on the presence of rodents. The prevalence of *P. muris* was higher in adult NR Voles and in males. Fifteen of nineteen infected NR Voles were adults while adults comprised only 24.2% of the captured NR Voles. Infection rates for adult males were the highest for any sex and age group (5.9%), followed by infection rates of 2.4%, 0.4%, 0.2% for adult females,

immature males, and immature females, respectively. The sex ratios of captured NR Voles did not vary significantly between the three major habitats sampled, but mature forest habitats had significantly fewer adults (13%) ($x^2 = 22.0$, $p > 0.05$) compared to 25% adults in 30 year-old birch-spruce forest habitats and 21% adults in 30 year-old Black Spruce forest habitats. Older animals have a longer opportunity to ingest the free living insects which serve as intermediate hosts and typically have higher infection rates. Higher levels of *P. muris* infection among older NR Voles is consistent with the pattern observed by Seidenberg et al. (1974) among Cotton Rats. However, while Seidenberg et al. (1974) reported a higher probability of infection in female Cotton Rats, twice as many male NR Voles were infected as females. Of the 1552 NR Voles captured, 54% were males. While predilection for infection of rodents of one sex seems doubtful, differential feeding on insects, home range size, or habitat preference may be explanations for differences in infection levels among males and females.

Infection with *P. muris* generally does not debilitate the host; however, one pathogenicity by *P. muris* in a field mouse was documented in East Germany (Krauss 1977). Examination of infected NR Voles during this study indicated all were in normal condition and all adults exhibited normal reproductive ability. Rausch and Tiner (1949) reported 20 *P. muris* in one Meadow Vole with no evidence of pathogenicity, no NR Vole examined on the Kenai Peninsula had an infection of that intensity.

Northern Red-back Voles had an average of 2.7 *P. muris* per infected individual with a range of 1–15. Thirteen of nineteen infected NR Voles (68%) only had one or two *P. muris* in their stomachs. Rausch and Tiner (1949) reported five infected Meadow Voles had an average of seven *P. muris* per infected vole. The largest *P. muris* measured during this study was 45 mm in length.

In summary, the nematode parasite *P. muris* appears to be restricted to Northern Red-backed Voles inhabiting Black Spruce or relatively moist habitats and occurs at low intensity in the vole population. The annual infection rates of *P. muris* in Northern Red-backed Voles did not vary significantly. Adult and male Northern Red-backed Voles were the primary rodent host for *P. muris*. No evidence of pathogenicity was documented.

Acknowledgments

I gratefully acknowledge the assistance for Mr. K. A. Neiland for identifying *P. muris* and thank both him and Dr. R. L. Rausch for providing information about the parasite and reviewing the manuscript. I also thank Dr. T. N. Bailey and two anonymous reviewers for comments that improved the manuscript. Funding for this project was provided by the U.S. Fish and Wildlife Service.

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Received 5 December 1983
Accepted 30 September 1984

Selection of Garden Residues by Alaska Moose, *Alces alces,* During Winter

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Herlugson, Christopher J., Jay D. McKendrick, and Mary Lou Herlugson. 1985. Selection of garden residues by Alaska Moose, *Alces alces,* during winter. Canadian Field-Naturalist 99(3): 389–391.

From January through March 1983, five Moose (*Alces alces*) were observed feeding in gardens and experimental plots at the University of Alaska Agricultural Experiment Station in Palmer. The Moose ate cabbage, brussels sprouts, and turnip roots, but largely avoided broccoli. All garden residues had a high nutritive value with cabbage, brussels sprouts, and turnip roots being highest. Garden residues are a high-quality forage which may function to increase overall digestive efficiency of Moose during winter.

Key Words: Alaska, *Alces alces, Brassica,* composition, Cruciferae, food, gardens, Moose, selection, winter.

From January through March 1983, Moose (*Alces alces*) were observed feeding in six gardens and two experimental plots at the University of Alaska Agricultural Experiment Station (AES) in Palmer, Alaska. Moose were observed digging through snow to feed on turnip roots, cabbage, and brussels sprouts. Moose also consumed small amounts of broccoli and onion tops, but ignored corn, beans, pea vines, and ornamental flowers left in gardens. The purposes of this study were to quantify selection of different garden residues by Moose and to describe nutritional composition of the residues.

Materials and Methods

Although not marked, the Moose were identified as a bull calf, a solitary cow, a cow and calf, and a mature bull. These Moose fed at AES from 12 January until 29 March 1983. Gardens and experimental plots were examined on 13 January to determine what residues were available and what had been eaten, and then reexamined daily until 29 March when the Moose left the area.

Samples of crop residues were collected for nutritional analysis on 13 January. They were analyzed for dry matter (DM), fiber components (Goering and Van Soest 1970, Mould and Robbins 1981), in vitro digestibility (IVDMD) using cow rumen fluid (Tilley and Terry 1963), total non-structural carbohydrates (TNC) (Smith 1969, 1979), and nitrogen and phosphorus (Brundage et al. 1981). Concentrations of other macro- and micro-elements were determined by atomic absorption spectroscopy.

Results and Discussion

The initial census of gardens and experimental plots showed that Moose were selecting brussels sprouts and avoiding broccoli; selection of cabbage was not evident (Table 1). By 15 February 1983, all brussels sprouts and cabbage plants had been consumed entirely and Moose began to eat turnip roots. When Moose left the area on 29 March, all turnip roots had been fed on to some degree. Results of laboratory analyses (Table 2) were related to selection of residues by Moose (Table 1).

Broccoli leaves had over twice the %DM of all other garden residues (Table 2). Brussels sprouts heads and stalks were comparable in %DM to broccoli stalks. Turnip roots, cabbage, and brussels sprouts leaves were lower in %DM and therefore higher in % moisture. When feeding in gardens on broccoli and brussels sprouts plants, Moose usually ate leaves first, then consumed stalks. The relatively high %DM of broccoli leaves may have functioned as a negative selection factor for this plant.

Garden residues were high in crude protein. Elevated levels of crude protein increase carbohydrate conversion to bacterial cell material in domestic ruminants (Russell et al. 1983) and may serve a similar function in wild ruminants such as Moose.

Digestibility (IVDMD) was highest for the preferred forages (cabbage, brussels sprouts, and turnip roots) and lowest for broccoli (Table 2). Even though broccoli stalks had the lowest digestibility of the garden residues, they were still 39% higher in digestibility than browses normally consumed by Moose (Oldemeyer 1974, Oldemeyer et al. 1977).

Total carbohydrate content (cellulose + hemicellulose + TNC) was highest in broccoli stalks (59.8%) and lowest in brussels sprouts leaves (32.6%). TNC for preferred forages was higher than in broccoli (Table 2). Structural carbohydrates (cellulose and hemicellulose) and lignin were highest in broccoli and lower in preferred forages. Broccoli was higher in hemicellulose than browses analyzed colorimetrically

TABLE 1. Selection of brussels sprouts, cabbage, and broccoli by Alaska Moose, 13 January 1983.

Plant Type	Number of Plants Available	%[a] of Available Plants Consumed
Brussels Sprouts	186	84.9
Cabbage	86	40.7
Broccoli	718	9.7

[a](number eaten/total number available) × 100
Note: Turnip roots were not counted at the beginning of the study because they were covered by about 15 cm of snow.

by Mould and Robbins (1981). Crude fat values for garden residues (Table 2) were within the range for forages reported by Van Soest (1982).

Garden residues (Table 3) exceeded winter browses (Kubota et al. 1970, Oldemeyer et al. 1977) for all macro- and micro-elements analyzed. Only broccoli leaves and stalks were lower in copper (Cu) than the 4–10 ppm level recommended for domestic ruminants (National Research Council 1975, 1976, 1978). Flynn et al. (1977) described the possible occurrence of Cu deficiency in a population of Alaska Moose on the Kenai Peninsula feeding on browses similar in composition to those reported by Kubota et al. (1970) and Oldemeyer et al. (1977). There have been no indications of Cu deficiency in Moose from the Palmer area (N. Steen, Game Biologist, Alaska Department of Fish and Game, Palmer, personal communication).

Currently, agriculture-wildlife interactions are minimal in Alaska. The most significant problem to date has been damage by introduced Bison (*Bison bison*) to barley crops (Gipson and McKendrick 1982) and domestic animal feed at the Delta Agricultural Project southeast of Fairbanks. However, long-range state plans call for further development of large-scale farming operations. Impacts of agriculture on wildlife and of wildlife on agriculture will need to be evaluated for the benefit of both.

Acknowledgments

We thank Charles T. Robbins for reviewing an earlier draft of the manuscript and an anonymous

TABLE 2. Percentages of dry matter (DM), protein, in vitro dry matter disappearance (IVDMD), neutral detergent fiber (NDF), acid detergent fiber (ADF), lignin, cellulose, total nonstructural carbohydrate (TNC), and crude fat in garden residues consumed by Alaska Moose, winter 1983. All values, except DM, expressed on a 100% DM basis.

Plant Type	DM	Protein[a]	IVDMD	NDF	ADF	Lignin	Cellulose	TNC	Crude Fat
Cabbage	9.5	20.74	95.6	17.3	10.0	2.2	12.3	22.5	0.80
Turnip Roots	6.2	14.01	93.9	21.8	13.6	4.9	16.6	17.8	0.45
Brussels Sprouts									
Heads	14.0	29.31	94.4	17.5	8.9	2.6	11.1	15.6	0.94
Leaves	9.7	27.20	85.4	25.6	16.3	4.5	15.4	7.9	2.56
Stalks	18.5	12.85	85.0	32.8	20.7	2.1	13.0	14.9	1.28
Broccoli									
Leaves	43.2	20.60	77.3	35.2	20.7	5.0	21.0	0.9	1.79
Stalks	19.0	9.79	66.6	57.9	39.6	8.8	37.4	4.1	0.98

[a]Protein = %N × 6.80 (Chibnall and Glover 1926, in Van Soest 1982)

TABLE 3. Macroelement (%), microelement (ppm), and ash (%) composition of garden residues consumed by Alaska Moose, winter 1983. All values expressed on a 100% DM basis.

Plant Type	Macroelements					Microelements				Total Ash
	P	K	Ca	Mg	Na	Cu	Zn	Mn	Fe	
Cabbage	0.62	3.45	0.44	0.21	0.05	5	36	26	197	11.0
Turnip Roots	0.72	4.56	0.75	0.25	0.15	7	26	27	320	16.5
Brussels Sprouts										
Heads	0.60	4.08	0.46	0.24	0.07	5	24	23	143	13.1
Leaves	0.53	3.55	1.39	0.29	0.12	8	22	45	1269	16.4
Stalks	0.43	2.66	0.61	0.26	0.10	5	27	15	144	9.3
Broccoli										
Leaves	0.63	2.28	4.80	0.26	0.35	2	22	42	597	23.5
Stalks	0.33	1.76	0.94	0.16	0.17	3	17	14	150	7.8

referee for providing substantive comments concerning presentation and organization.

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Received 18 October 1983
Accepted 24 October 1984

News and Comments

Notice of The Ottawa Field-Naturalists' Club Annual Business Meeting

The 107th Annual Business Meeting of the Ottawa Field-Naturalists' Club will be held in the auditorium of the Victoria Memorial Museum Building, Metcalfe and MacLeod Streets, Ottawa on Tuesday, 14 January 1986.

BARBARA MARTIN
Recording Secretary

Tenth North American Prairie Conference: Call for Participation

The Tenth North American Prairie Conference, sponsored by The Native Prairies Association of Texas in conjunction with the Texas Department of Agriculture, Texas General Land Office as well as Texas Woman's University, North Texas State University and other participating Universities, will be held on the campus of Texas's Woman's University in Denton, Texas from June 22 through June 26.

The theme for the Conference is "North American Prairie: the Roots of Our Culture, the Foundation of Our Economy."

The Conference is planned for Professionals, Researchers, and Educators to exchange data on native prairie eco-systems, past, present and future.

Proposals are encouraged — for papers, panels, workshops, etc.

Examples of suggested topics include:

- Grassland regions of Texas
- Buffalograss for lawns
- Eastern Gamagrass
- Native prairie grasses
- Prairie management
- Prairie geography
- Prairies as range resource
- Mycorrhizae & Rhizobia on the prairie
- Prairie ethics
- Prairie preservation
- Nutrition of the prehistoric indians
- Energy content of prairie soils
- Using prairie plants in landscaping
- Controlled burning of the Prairie
- Railroad prairies
- Nitrogen cycle
- Insects
- Prairie wetlands
- Taxonomy
- Small vertebrates
- Abiotic conditions
- Prairie folklore and literature
- Public interest generation

Send a one-page abstract of your panel or paper proposal to:

Program Committee
Native Prairies Association of Texas
T W U, P. O. Box 22675
Denton, Texas 76204

Deadline for proposals/abstracts is 15 December 1985.

All papers presented will be published in the Proceedings

NADINE M. SIMON
Conference Coordinator

Baillie Fund Grants 1985: Applications Welcome for 1986

In the last field year of the Ontario Atlas of Breeding Birds, the Trustees of the James L. Baillie Memorial Fund for Bird Research and Preservation were pleased to help support completion to the project through the awarding of 13 grants totalling $5600.00. Grants totalling $3400.00 were bestowed on six other projects: Status of Baird's Sparrow in Manitoba (Brian Ratcliff), Banding Study of House Finch Dispersal (Ontario Bird Banding Association, coordinated by Erica H. Dunn), Spotted Owl status in British Columbia (Federation of British Columbia Naturalists, coordinated by Hue MacKenzie), Surveys of the Northern Harrier in central southwestern Ontario (Al Sandilands), Innis Point Bird Observatory (Ottawa Banding Group), and Late fall bird movements at East Point, James Bay (R. Douglas McRae). The Federation of B.C. Naturalists were unable to use the grant in 1985, but hope to have the survey well underway next year.

Applications are welcome for funding in 1986. All projects must be conducted in Canada, but applicants may reside elsewhere. Although all types of bird

research are eligible for consideration, preference will be given to projects conducted by amateurs researchers and to those by professions who use a high level of amateur participation. Applicants lacking access to other funding sources will be given priority over applicants of similar quality with greater means of support.

All applications should be submitted on forms available from the Secretary, and should be postmarked by 31 December 1985 to be guaranteed consideration by the Trustees.

The current board of Trustees consists of Fred Bodsworth (Chairman), Robert Curry, Clive E. Goodwin, Dr. David J. T. Hussell, Dr. David M. Scott, Dr. J. Murray Speirs, and James Woodford. The chief source of funding is the Jim Baillie Birdathon conducted annually by the Long Point Bird Observatory, but direct donations are welcome and tax deductible. A receipt will be issued. Application forms and further information can be obtained from:

MARTIN K. MCNICHOLL,
Secretary, c/o Long Point Bird Observatory,

P.O. Box 160,
Port Rowan, Ontario
N0E 1M0.

Notice to News and Comment Contributors

Revised deadlines for material to appear *in this section* have now been set and potential contributors should bear them in mind when submitting copy, starting with Volume 100, Number 3, July–August 1986. No new copy can be accepted for Volume 99, Number 4, or Volume 100, Numbers 1 and 2.

Issue number	*Submit before*	*Issue quarter*
1	1 August	January–March
2	1 November	April–June
3	1 February	July–September
4	1 May	October–December

Notice of future meetings and conferences, grants available, and news of staff appointments or retirements of interest to the general natural history community with particular reference to Canada and the adjacent United States would be particularly welcome for this section.

These deadlines apply to final copy and not to research submissions (articles and notes) where extensive review and editing, and the amount of material on hand at any given time, may add to the publication time.

FRANCIS R. COOK
Editor

Erratum

For the article "More new and interesting grass records from southern Ontario" in *The Canadian Field-Naturalist* 99(2): 141–146 please note the third authors name should read (p. 141) R. S. W. BOBBETTE (*not* ROBBETTE as printed). The error is also repeated in the bibliographic strip (p. 141) and the table of contents (outside back cover).

FRANCIS R. COOK
Editor

Minutes of the 106th Annual Business Meeting of the Ottawa Field–Naturalists' Club: 8 January 1985

Place and Time: Auditorium, Victoria Memorial Museum Building, Metcalfe & McLeod Street, Ottawa. 20:10 hrs.

Chairman: Mr. F. Pope, President

Attendance: About 55 people attended the meeting.

1. Minutes of the previous meeting

B. Martin, Recording Secretary, read the minutes of the 105th Annual Business Meeting. It was moved by P. Martin (2nd D. Brunton) that the minutes be approved.

(Motion Carried)

Minutes of the 105th Annual Business Meeting of the Ottawa Field–Naturalists' Club: 10 January 1984

Place and Time: Auditorium, Victoria Memorial Museum Building, Metcalfe & McLeod Streets, Ottawa 20:05 hrs.
Chairman: Mr. D. Brunton, President
Attendance: About 80 people attended the meeting.

1. *Minutes of the Previous Meeting*:
E. F. Pope, Recording Secretary, read the minutes of the 104th Annual Business Meeting. It was moved by S. Gawn (2nd G. Hamre) that the minutes be approved.
(Motion Carried)

2. *Business Arising from the Minutes*:
The President observed, with pleasure, that the publications policy statement appeared in Volume 97, Number 2 of *The Canadian Field–Naturalist*, an advance copy of which he displayed.

3. *Finance*:
W. Arthurs presented the financial statements.
The following comments were made:
(a) It was observed that the $100 earned from the sale of shrubs was included in the $641 Seedathon Fund, under liabilities on the balance sheet.
(b) A member expressed disappointment that the amount of money collected in memory of Anne Hanes was not shown on the balance sheet. The amount was $630.
It was moved by W. Arthurs (2nd R. Taylor) that the financial statement be accepted
(Motion Carried)

4. *Report of Council*
The report was read by D. Brunton and F. Pope. After each committee report there was an opportunity for comments. Comments included:
(a) F.O.N. Conference Committee
The Committee was congratulated for a job well done.
(b) Macoun Field Club Committee
The President added that a meeting had been scheduled with officials from the National Museum of Natural Sciences to discuss the future of the Macoun Club.
The Chairman of the Committee, supported by another person, warned that the Macoun Club was in danger of disbanding because of lack of leadership.
(c) Membership Committee
The President reported the recent death of Vi Humphreys, long time member of the Membership Committee, 35 year member of the Club and tireless supporter of Club activities. An official letter of sympathy had been sent to her sister and many Club members had visited the funeral home.
(d) Publications Committee
E. Dickson reported that there had been little response to the appeal on the fee renewal form for proof-reading and typing assistance for *The Canadian Field–Naturalist*.
R.Taylor said that J. Sankey had agreed to edit *The Shrike*.
(e) Study Group
A member was informed that one could contact a study group co-ordinator by calling the Club telephone number.
It was moved by S. Gawn (2nd M. Brigham) that the Report of Council be accepted.
(Motion Carried)

5. *Nominations*:
R. Taylor, Chairman of the Nominations Committee, presented the following slate for the 1984 Council. Each candidate was introduced.

President	E. F. Pope
Vice-President	W. K. Gummer
Vice-President	W. R. Arthurs
Recording Secretary	G. M. Hamre
Corresponding Secretary	B. Martin
Treasurer	P. D. M. Ward

Other Members of the Council:

R. E. Bedford	F. R. Cook
*D. F. Brunton	E. M. Dickson
B. A. Campbell	S. Gawn
W. J. Cody	J. M. Gillett
C. G. Gruchy	B. M. Marwood
D. R. Laubitz	P. Narraway
L. S. Maltby	K. W. Taylor
A. Martell	R. Taylor
P. M. D. Martin	

*Past President

It was moved by R. Taylor (2nd D. Laubitz) that the slate of nominations be approved.
(Motion Carried)

The President thanked the retiring members of the Council for their services. Retiring were: P. Catling, S. Darbyshire, T. Hanrahan, S. Hamill, E. Munroe and P. Walker. He then welcomed the new members of the Council: B. Martin, L. Maltby, A. Martell and J. Gillett (appointed in September 1983).

6. *Nomination of Auditor*:
W. Arthurs moved (2nd K. Taylor) that F. M. Brigham be appointed to audit the accounts of The Ottawa Field-Naturalists' Club for the 1983-84 fiscal year.
(Motion Carried)

7. *New Business*
(a) Motion to change the name of the Club.
The President announced that the motion could not be brought to a vote because it had not been "published in *The Canadian Field-Naturalist* at least one month before ... The Annual Business Meeting" (Article 23 of the Constitution). In fact, it was printed in Vol. 97 No. 2, the advance copy of which he had displayed earlier.
R. Taylor, author of the motion, said that, in practice, few people wrote the Club name correctly and it was a constant problem for editors. He hoped for a discussion on the topic. In order of priority, he most wanted first to eliminate the hyphen, second "The", third the apostrophe and fourth "Club".
F. Pope reported that official Club records were inconsistent. The official letter of incorporation, dated 29 February 1884, does not display a hyphen in the name. Issues of the official journal that year and later do not include "The" in the Club name either. The hyphen first appeared in the official journal in 1888.
F. Pope added that the procedure for changing the Club name was to apply for supplementary letters patent. This would involve a $52 filing fee plus the cost of a title search. Another option was to register a "style name" which costs $10. The official name must be used for legal transactions such as opening bank accounts or purchasing property but the style name could be used for all other purposes. The style name could be "Ottawa Field Naturalists" while the official name remained "The Ottawa Field-Naturalists' Club".
Most of the comments from the floor supported retention of the present name although there seemed little objection to eliminating the hyphen. Apparently this issue was debated about 20 years ago.
(b) E. Dickson reported that the group seeking a suitable "objet d'art" to serve as a permanent trophy for the Anne Hanes Natural History Award had decided instead to invest the money and to spend the interest on trophies that could be retained by each winner. This will require the establishment of a fund for the purpose. The original idea had been simply to spend the whole sum collected upon a permanent trophy.
(c) G. McGee announced that the Bird Study Group would hold regular monthly bird recognition workshops in the Victoria Museum Building.
(d) The outgoing president expressed his appreciation for the significant contributions made by the many people who are active in Club affairs.
(e) The incoming president then made a few remarks.

8. *Adjournment*:
It was moved by H. Thomson (2nd R. Taylor) that the meeting adjourn.
Time: 21:40 hrs. (Motion Carried)

9. Following the business meeting a film, entitled "The Changing Forest" was shown. After the film the group met for coffee.

E. F. POPE
Recording Secretary

2. Business Arising from the Minutes:

The President brought up the motion to change the name of the Club for pragmatic reasons — to eliminate in descending priority: the hyphen, the 'The', the apostrophe, and the 'Club'.

F. Pope informed the meeting that many corporations do change parts of their names such as a letter or a hyphen and according to our lawyer, such minor changes do not really matter.

The following points were made in the ensuing discussion:

a) The word "club" denotes leisure-time activity and detracts from the professional image the Club should project in its lobbying endeavours.
b) Whichever name is decided upon should be grammatically correct, that is if the apostrophe is eliminated, the word 'Club' must go too.
c) The word "club" is useful in distinguishing our Club from the Federation of Ontario Naturalists when acronyms are used
d) Don't change the name of the Club in the Constitution because the name has been around a long time. It is well known by this name.
e) If a style name is to be adopted, have Council create a bylaw to give this name some credence.

The general concensus was to leave the Club name intact, but to adopt an alternate style name. Accordingly, the motion of R.Taylor and J. Reddoch to change the name of the Club from "The Ottawa Field-Naturalists' Club" to "Ottawa Field Naturalists", the details of which can be found in *The Canadian Field-Naturalist* 97(2): 227, was voted upon.
(Motion Lost)

D. Brunton moved (2nd J. Reddoch) to ask Council to place the style name of 'Ottawa Field Naturalists' in the bylaws. (Motion Carried)

3. Finance

M. Brigham presented the financial statements.
The following comments were made:

a) The separate reserve fund for *The Canadian Field-Naturalist* was lumped with other small reserve funds.
b) The expenditures of Education and Publicity Committee (about $70.00) does not appear as a separate item under EXPENDITURE.
c) The purchase of the printer for *Trail & Landscape* does not appear as a separate item.
d) The Anne Hanes Natural History fund does not appear with the other memorial funds.

e) Expenditures on Shrike publishing should read \$657.00. The computer cost associated with the Shrike (\$420.00) should be added to "Computer Charges".

M. Brigham moved (2nd S. Hamill) to accept the financial statement with amendments.

(Motion Carried)

Auditor's Report

To: Members of The Ottawa Field-Naturalists' Club

I have examined the balance sheet of The Ottawa Field-Naturalists' Club as at September 30, 1984, and the related Income Statements for the year then ended. My examination included a general review of the accounting procedures and such tests of the records and supporting vouchers as considered necessary under the circumstances.

In my opinion, these financial statements present fairly the financial position of the organization as at September 30, 1984, and the results of its operations for the year then ended in accordance with generally accepted accounting principles.

F. MONTGOMERY BRIGHAM

January 4, 1985

The Ottawa Field-Naturalists' Club
Balance Sheet as of September 30, 1984*

Assets

Current		
Cash and Term Deposits	\$77 277	
Accounts Receivable	21 024	
Accrued Interest	2 562	
Prepaid Expenses	1 305	\$102 168
Fixed		
Equipment		
Less: Accumulated Depreciation	1 468	
Land: Alfred Bog	3 152	4 620
Total Assets		\$106 788

Liabilities and Members' Equity

Current Liabilities		
Accounts Payable	\$23 599	
Deferred Income	10 763	\$ 34 362
Memorial Funds		
Baldwin	163	
Father Banim	50	
Anne Hanes	630	843
Other Funds		
Carp Hills	200	
Alfred Bog Protection	3 135	
Seedathon	1 269	4 604
Members' Equity		
Balance October 1, 1983	56 892	
Income over Expenditure for Year		
The Ottawa Field Naturalists' Club	4 156	
The Canadian Field Naturalist	5 458	
Net Income — Centennial Projects	473	66 979
Total Liabilities and Members' Equity		\$106 788

*as amended at the request of Council, this report.

Statement of Income and Expenditure
The Ottawa Field-Naturalists Club
for the year ended September 30, 1984

Income			
Apportionment of Membership Fees			
Annual	$11 764		
Life	nil	$11 764	
Trail & Landscape			
Subscriptions	421		
Back Numbers	36		
Other Revenue	450	907	
Shrike Subscriptions		658	
Donations		2 943	
		16 272	
Interest		1 297	$17 569
Expenditure			
Trail & Landscape			
Publishing	5 130		
Circulation	305		
Editing and Office	165		
Honoraria	550	6 150	
Shrike Publishing	685		
Data Base	392	1 077	
Committee Activities — Net			
Excursions and Lectures —	(276)		
Membership	1 059		
Macoun Club	301		
Conservation	188		
Bird Records / Bird Feeders	108		
Publications	53		
Affiliation Fees	281		
Baldwin Scholarship	150		
Office Assistant	416		
Office Supplies and Expenses	1 982		
Computer Charges	1 449		
Miscellaneous	475	6 186	13 413
Excess of Income over Expenditure			$ 4 156

Statement of Income and Expenditure
The Canadian Field-Naturalist
for the year ended September 30, 1984

Income			
Apportionment of Membership Fees			
Annual	$ 8 043		
Life	nil	$ 8 043	
Subscriptions		20 591	
Publication			
Reprints	12 816		
Plates and Tab Settings	2 045		
Extra Pages	16 890		
Back Numbers	2 341	34 092	
Other			
Interest	4 989		
Exchange	1 715	6 704	$69 430
Expenditure			
Publishing	42 997		
Reprints	7 250	50 247	
Circulation		8 562	
Editing and Expenses		140	
Office Assistant		2 713	
Office Supplies		289	
Honoraria		2 021	63 972
Excess of Income over Expenditure			$ 5 458

4. Report by the Council to the Ottawa Field-Naturalists' Club 1984

This report consists of reports by Committees of the Council.

Awards Committee

The Committee retained most of its existing membership for continuity, and this membership is expected to remain unchanged until recipients of 1984 awards have been named early in 1985. Thirty nominations were received at the end of 1983, indicating an increased interest in, and acceptance of, the awards system.

All Committee recommendations to Council were accepted, the following recipients being named:

Honorary Member	— Irwin Brodo Bernard Boivin Verna Ross McGriffin Stewart MacDonald
Member of the Year	— Rick Leavens
Service Award	— Stephen Darbyshire
Conservation Award	— Ernie Beauchesne/ Don Cuddy
Anne Hanes Natural History Award	— Bruce di Labio

The new Honorary Members bring the number in this group to nineteen. All recipients were presently at the 1984 Soirée and received their certificates from the President, Frank Pope. A report on the winners, with their citations, appeared in *Trail & Landscape,* Vol. 18, No. 4, and will appear in *The Canadian Field-Naturalist.*

A new feature introduced during the year is the production of "Tributes to Past Members", to be published in both *Trail & Landscape* and *The Canadian Field-Naturalist.* This is a system whereby the Club can pay formal and public tribute to deceased members who have played a major role in Club growth and activities. At present this function rests with Awards Committee.

Information has been assembled on awards given by 12 other organizations; the Committee will consider the suitability of nominating Ottawa Field Naturalists' Club members for these outside awards.

A number of nominations have been received for consideration for 1984 awards.

(W.K. Gummer)

Birds Committee

The 1984 Birds Committee (BC) consisted of 9 members: V. Bernard Ladouceur (chairman), Mark Gawn (vice-chairman), C. Wright Smith (secretary, Frank H. Bell, Robert A. Bracken, Stephen Gawn, Christine Hanrahan, Gordon Pringle, and Daniel Toussaient (President of club des ornithnologues de l'Outaouais — C.O.O.)

Major items of business included the assumption of direct control of the Ottawa Region (Region 24) of the Ontario Breeding Bird Atlas (OBBA), the formation of an agreement between *The Shrike* (an Ottawa Field-Naturalists' Club publication) and the Birds committee to solicit rare bird reports from contributors to *The Shrike*, the financial and running of the Ottawa Field-Naturalists' Club bird feeders, a revamping of the rare bird alert system, and the organization of the Ottawa Christmas bird census as well as owl, spring and fall counts.

After being under the command of one person (Bruce Di Labio) for three years, the Birds committee was asked to take over the Ottawa Region of the Ontario Breeding Bird Atlas. Considering the amount of work involved it was decided that a committee would best complete the task. The Ontario Breeding Bird Atlas subcommittee was formed and it included as its members C. Hanrahan (chairman), F.H. Bell, M. Gawn, and R. John. Adequate coverage of the 77 squares in the Ottawa Region has been increased from 62% at the beginning of 1984 to 92%. Twenty-six additional squares were assigned to Ottawa and were also covered adequately in 92% of the cases. Eleven more squares have been added for 1985. Some of the success is due to "square bashing" (where a number of birders do the same square) on evenings and weekends. The "square bashing" was organized by M. Gawn.

This year's edition of the Bird Records Subcommittee (BRS) included M. Gawn (chairman), R.A. Bracken, F.M. Brigham, Roger A. Foxall, Bob Gorman, Roy John and Michael Runtz. R. Foxall was later replaced by V.B. Ladouceur. G. Pringle was the non-voting secretary. The most important accomplishment was an agreement made with *The Shrike* to require of its contributors written reports on all "rare" species (as defined by the Bird Records Subcommittee). The Bird Records Subcommittee has also decided to hold regular, monthly meetings and is presently up-to-date in its assessment of rare bird reports.

Gordon Pringle was again responsible for the administration of bird feeders. The Ottawa Field-Naturalists' Club will, again, operate four feeders for the winter of 1984-85 including sites at Pink road (in co-operation with the club des ornithnologues de l'Outaouais), Jack Pine Trail, Davidson Road, and Rockcliffe. G. Pringle negotiated the purchase of forty-pound bags of mixed sunflower seeds for the upcoming winter. The fourth annual "seed-a-thon" took place 9 September. V.B. Ladouceur raised about

$400 for the purposes of purchasing seed for the Ottawa Field- Naturalists' Club feeders.

An *ad hoc* Committee was struck to revamp the rare bird alert. The members are V.B. Ladouceur (chairman), M. Gawn, R. John, and C.W. Smith. As of the last meeting, a two-tier list has been proposed. The "A-List" would resemble the present list except that only extremely rare species would be listed. The "B-List" would consist of less rare species and only those interested in *pursuing* such would be given membership.

The 1984 Christmas bird count will, again, be compiled by V.B. Ladouceur, assisted by C. Hanrahan. Changes for this year include reverting to seven areas, re-instating the Aylmer East (Lucerne) area, and a plan to more accurately census waterfowl and gulls by having observers do simultaneous counts three times during the count day.

The owl census was incorporated into the Ontario Breeding bird Atlas program this year, although, not all that successfully. Next year, a broader program is to be implemented to gather Ontario Breeding Bird Atlas data concerning all "crepuscular" species (including Henslow's sparrow).

The spring and fall bird counts were held 27 May and 2 September, respectively, each being compiled by V.B. Ladouceur. Interest in these activities seems to be waning. However, it is the feeling of many Bird Committee members that these events should continue as vehicles to "bring along" new birders.

Of course, many other more minor items were discussed and recorded in the Bird Committee minutes.

The major agenda for 1985 includes the final year of the Ontario Breeding Bird Atlas program, a new Ottawa bird checklist, and a redefining of the BRS' terms of reference. I extend many thanks to those who assisted in the administration of 1984's birding activities.

(V. Bernard Ladouceur)

Conservation Committee

In 1984 the Conservation Committee continued its involvement in local, provincial and national issues.

The Alfred Bog issue, a priority for the Conservation Committee in 1983, continued to keep a high profile in 1984. The Conservation Committee is pursuing a plan of land acquisition on a priority basis within the wetland, with five desirable areas for purchase within the Bog having been identified. Fundraising will continue in order to support acquisition of smaller parcels. Liaison continues with the Vankleek Hill Nature Society, the Federation of Ontario Naturalists, and the Nature Conservancy of Canada on this issue, and representation is to be made to Wildlife Habitat Canada with regard to Alfred Bog purchase. The ultimate aim is to preserve Alfred Bog as a nature reserve.

The Carp Hills subdivision proposal has developed into a priority issue for the Conservation Committee. The refusal of the Regional Municipality of Ottawa-Carleton to purchase the Aselford-Bradley property was a serious blow to conservation in the region. The Carp Ridge is considered to be a priority conservation land in RMOC because of its diversity and accessibility. The area contains deer yards, heronries, wetlands and scenic value. The Carp Hills Action Committee was formed with representation from The Ottawa Field-Naturalists' Club, National Provincial Parks Association and concerned landowners. A close 17-14 vote against acquisition of land in the Hills by RMOC executive council has encouraged The Ottawa Field--Naturalists' Club to request a referral of the Carp Hills issue to the Ontario Municipal Board. The City of Ottawa has provided The Ottawa Field-Naturalists' Club with $20 000.00 for legal/financial advice and funding for the referral process. The Conservation Committee looks forward to the hearing which is to be held early in 1985.

Committee members have continued to represent The Ottawa Field-Naturalists' Club on the Marlborough Forest advisory committee. The draft five-year plan for the Forest prepared by MNR is a disappointment, and involvement in this issue is ongoing. Active involvement continues regarding the route selected for Hydro's Eastern Ontario transmission lines from Kingston to Ottawa and from Cornwall to Ottawa with concern being expressed over several wetlands and natural areas that may be affected by the line.

The Province of Ontario's announcement of Guidelines for Wetland Management in Ontario (April 1984) was cause for both encouragement and concern. While the Guidelines are an expression of the Province's commitment to responsible wetland management in Ontario, the content of the Guidelines provides no assurances that wetland conservation will be realized or that a Policy statement on wetlands will be soon forthcoming. Committee members met on several occasions with MPP's, including the Eastern Caucus meeting, to express concerns and encourage prompt action towards developing the Guidelines into a Policy.

On the National scene, the Committee sent a brief to the task force studying the Canada Water Act. This brief outlines the importance of wetlands and requests that consideration be given to wetlands as a resource.

The Conservation Committee has exchanged correspondence, attended meetings or commented on a number of other issues, including parks issues in Brit-

ish Columbia, Manitoba and Ontario; recycling garbage in Ontario; Environmental Non-government Organizations (ENGO); Britannia Woods storm sewer study; Stewartville Swamp purchase proposal; the wolf problem in British Columbia, and many others.

We wish to thank all members of the Committee for their active involvement in these many projects.

(E. Bottomley, L. Maltby)

Education and Publicity Committee

During 1984, on behalf of the Club, the Education and Publicity Committee set up an exhibit at the Ottawa Duck Club Wildlife Art Show, and a sales booth at The Ottawa Field-Naturalists' Club Soiree.

Leaders were recruited for a senior citizens' walk and for an outing conducted *en francais* for an adult French class.

Speakers were obtained for several Ottawa-area organizations. A church women's group was shown nature slides and learned about the history and the various activities of The Ottawa Field-Naturalists' Club. The Beacon Hill Lodge nursing home was supplied with a series of speakers presenting illustrated talks on a variety of nature subjects. A day-camp operator was given some advice on activities and natural areas of interest to youngsters, and two Wolf Cub packs were introduced to the subject of winter birds and bird feeders.

The Education and Publicity Committee once again co-ordinated the judging and presentation of The Ottawa Field-Naturalists' Club special awards at the Ottawa Regional Science Fair. The 1984 winners were Amanda Tower, for her experiments on the effects of irradiation of seeds on plant growth, Hee-Yun Park and Christine Kenney, for their mushroom exhibit, and Helen Ford, for her project on molds. Each winner received a cash prize and a one-year membership in The Ottawa Field-Naturalists' Club.

Through the efforts of Mr. George McGee, a set of bird slides was obtained from Cornell University. These slides, combined with accompanying notes produced by George, form an educational package for use in the classroom or in other less formal settings.

Work is continuing on the revision of Mr. McGee's *Birds, Botany and Geology* brochure.

We were saddened by the death, in October, of Mrs. Josephine Carson, who had been a member of the Committee for two years. Mrs. Carson, an excellent photographer, is greatly missed by her friends in the Club.

I would like to thank the members of the Education and Publicity Committee and all the others who made our various activities successful.

(K. Taylor)

Excursions and Lectures Committee

Forty-eight excursions were organized by the Committee during the year. These comprised 12 of general interest, and 17 with particular reference to birds, 5 botany, 1 amphibians, 1 mushrooms, 1 geology, 1 ferns, 1 jointly for birds and butterflies and 1 butterflies. As well, there were 4 bird walks for beginners, 1 canoe trip, and 4 major trips to Kingston with the Kingston Field Naturalists, a Spring Outing at Presqu'Ile and Hawk Migration at Derby Hill. All the excursions were well attended and seem to have been enjoyed by the participants, though the weather on some of them was not as accommodating as in previous years.

There were nine monthly meetings as well as the Annual Business Meeting, held in the auditorium of the Museum of Man and Natural Sciences. Titles of the evening presentations included "Bird Banding in Ottawa", "A Trip to Northern Ellesmere Island", "A Visit to Kruger National Park", "Retracing the Route of the Klondike Gold Rush", "Rare Gulls of the Arctic", "Sharing a Dream: A Film Journey through Queensland and the Northern Territory of Australia, and "Australia in April".

On two occasions The Ottawa Field-Naturalists' Club members participated directly and with obvious enthusiasm in a workshop on Plant Folklore and Edible Wild Plants, and at the customary Members' slide night.

The Annual Soirée, held at the First Unitarian Church on 4 May, was a great success. One hundred and forty-eight people attended the wine and cheese party, and there were a number of excellent exhibits contributed by various Ottawa Field-Naturalists' Club members, the Federation of Ontario Naturalists, the National Capital Commission, the Rideau Valley Conservation Authority and the Rideau Trail Association. An account of this event is given in *Trail & Landscape* 18: 168-169.

The Committee wishes to express its sincere thanks to speakers and leaders. We are also grateful to the National Museum of Natural Sciences for the use of its facilities and for the provision of the Dinobus on outings.

(P. Martin)

Finance Committee

The Committee met twice in 1984. At the first meeting, on 31 January, Terms of Reference produced in 1978 were revised and presented to Council for approval. In addition, The Ottawa Field-Naturalists' Club Financial Policies were discussed, amended and submitted to Council for approval.

At the second meeting the Finance Committee met with the Publications Committee to establish a policy

and to make recommendations to Council on the pricing of the Club's 'products', such as special publications, sound tapes, etc.

Budgets were prepared for the 1984/85 fiscal year for both the Ottawa Field Naturalists' Club and *The Canadian Field-Naturalist.*

During 1984 Club funds were invested in Government of Canada treasury bills. Yields from this source were higher than those produced from previous methods of investment.

(W.R. Arthurs)

Macoun Field Club

At the end of the 1983-84 school year Stephen Darbyshire stepped down as Chairman and Co-ordinator of the Macoun Field Club. The Ottawa Field-Naturalists' Club owes Stephen a debt of gratitude for the five years during which he put a great deal of time and effort into ensuring that the Macoun Club continued to operate.

Robin Collins has taken over from Stephen, and now that he has found his feet and got the feel of the Club he could use some help both in the meetings and on field trips. While several people have kindly offered to help on an ongoing basis, we also need speakers and trip leaders for just one meeting during the year – not a very onerous assignment.

The Macoun Club currently has 14 senior, 21 intermediate, and 26 junior members. They are an active and intelligent group, but Robin finds serious deficiencies in their biological training, which he feels reflect poorly on their schools. While members seem to be well informed on such topical subjects as acid rain, they appear to have little knowledge about Darwin and evolution. What we need are programmes and speakers to inspire the Club members to exert their own initiative to study, using a solid grounding from the past, the problems that may affect us in the future. The future of not only the Macoun Field Club but also perhaps of us all depends on the education and motivation of a new generation of naturalists.

(R. Collins, D. Laubitz)

Membership Committee

Membership in the Club declined slightly in 1984. Local membership declined by 13 and non-local membership declined by 32. The number of new members joining the Club in 1984 was 168, a decrease of 29 from 1983. The total membership in the Club as of December, 1984, was 1233, a decrease of 45 from the 1983 total of 1278. Family memberships totalled 323. Based on an average of two members per family, we estimate the total membership served by the Club to be 1556.

The accompanying table shows a tabulation of membership distribution. The figures in brackets contain 1983 totals.

This year four honorary memberships were presented. The recipients were Dr. Irwin M. Brodo, Dr. Bernard Boivin, Verna Ross McGiffin and Stewart D. MacDonald.

The 1983 Volunteer List was updated by the addition of 34 new volunteers. These lists are circulated to all Committees of the Club. The volunteers have a broad diversity of knowledge and experience which can be of significant benefit to the Club.

Membership cards were again mailed with the 1984 membership renewal forms. These are sent in anticipation of membership payment and consequently reduce expenses by about $400.00.

The Membership Committee organized a raffle which was held at The Ottawa Field-Naturalists' Club Soirée. Paul Harpley donated one of his limited edition prints entitled "Canada Lynx" and Rick Leavens held the winning ticket. The profit of $766.80 was donated to the Alfred Bog Fund. I wish to thank everyone who contributed to the success of this venture.

The Membership Committee lost a very able and helpful member when Violet Humphreys passed away last January. Vi was always there to give a hand and to encourage and we truly miss her friendship.

Lastly, I wish to thank all the members of the Committee for their support and co-operation: Eleanor Bottomley, Ellaine Dickson, Fran Goodspeed,

Membership in the Ottawa Field-Naturalists' Club, 1984

Type	Canada		Foreign		Totals
	Local	Other	USA	Other	
Individual	463 (482)	295 (318)	68 (78)	5 (6)	831 (884)
Family	291 (291)	31 (28)	1 (2)	0 (1)	323 (322)
Sustaining	24 (23)	3 (2)	0 (1)	0 (0)	27 (26)
Life	12 (10)	18 (18)	3 (3)	1 (1)	34 (32)
Honorary	13 (10)	4 (3)	1 (1)	0 (0)	18 (14)
	803 (816)	351 (369)	73 (85)	6 (8)	1233 (1278)

Luella Howden, Barbara Martin, Aileen Mason, Bette Stein and Ken Strang. Special thanks go to Patricia Narraway for her much appreciated help in overseeing the computer programs.

(B. Campbell)

Publications Committee

The Publications Committee continued to function in its role of overseer of, and advisory body to, Council on the Club's various publications.

A year ago we reported that *The Canadian Field-Naturalist* had had a difficult year, as a result of which only two issues were published. We are now happy to report that these difficulties have been largely overcome and that great strides have been made towards getting the publication schedule back on track. Six issues have appeared in 1984: Volume *97*, issues 2-4, andd Volume *98*, issues 1-3. Statistically, these comprise 762 pages, 60 articles, 51 notes, 74 book reviews, 556 new titles, 2 commemorative tributes, and many pages of news and comments. Amongst the articles were numbers 4 and 5 on the Biological Flora of Canada. The journal appears to be in a healthy state with manuscripts on hand for almost all of Volume *99*. There were no changes in Associate Editorships. No funds from external sources were required to defray publication costs.

Trail & Landscape continues to flourish and to increase in stature. A year ago we forecast reduced paging in 1984, but we were wrong. Five issues with a total of 288 pages were published, the largest number ever. The usual fine selection of articles on all aspects of local natural history included several of the 'field identification' type (water milfoils, larval fishes, oatgrasses) that should be especially useful to those members who enjoy 'knowing what they see' in the field. This year the Club has purchased a printer that is compatible with the editor's home computer for the exclusive use of *Trail & Landscape*. This printer was purchased with the bequest of Elisabeth Slasor. This has significantly increased the efficiency of production by reducing the typing and editing time and producing camera-ready copy. It is intended to produce a cumulative index to *Trail & Landscape* with the completion of Volume *20*, two years hence.

The Shrike underwent a change of editor in 1984. The Publications Committee extends its thanks to T. Hanrahan for his work as editor of Volume *7*, and welcomes the new editor, J. Sankey, who has done a creditable job with Volume 8. Six issues appeared in 1984: Volume *8*, issues 5, 6 and Volume *9*, issues 1-4 for a total of 137 pages. The editorial staff is continuing to experiment with ways of presenting the large body of data that accumulates through computer-stored records of bird sightings. An excellent field-guide sized summary of 1981-83 observations appeared in Volume *9*, issue 1.

One manuscript is under consideration for publication as a Special Publication. If external funding can be obtained, it is intended to publish this in 1985.

The Publications Committee extends its thanks to the editorial and production staffs of all three publications for their continued generous support and service to the Club.

(R.E. Bedford)

The report was read by F. Pope and W. Gummer.

After each committee report there was an opportunity for comments. Comments included:

(a) *Conservation Committee*

F. Pope reported that the hearing at the Supreme Court of Ontario with regard to the actions of the Regional Municipality of Ottawa-Carleton with respect to the Carp Hills should take place soon.

F. Pope reported on the Club's bid to buy some land in Alfred Bog. J. Reddoch had brought to the Club's attention a notice in the Ottawa Citizen advertising land for sale on the periphery of the Bog. Accordingly, the O.F.N.C. put in a bid for the 100 acres. There were four bids in all — two below ours and one above. The property went to a farmer with adjoining land. S. Hamill remarked that although it would have been nice to acquire this land, it is of marginal use and therefore no great loss.

W. Knight enquired if the Club owned any land at all in Alfred Bog. F. Pope replied that the O.F.N.C. owned 50 acres in the middle.

F. Pope reported on the progress of the proposal submitted to Wildlife Habitat Canada by D. Cuddy and P. Catling for funding for Alfred Bog. The proposal is too large to be considered for the remainder of this fiscal year, but it is on the agenda of the spring meeting.

F. Pope reminded members of the extensive cuts to the Canadian Wildlife Service and urged them to continue writing to the relevant politicians.

(b) *Excursions and Lectures Committee*

A sincere thanks to all those who provided refreshments throughout the year.

(c) *Membership Committee*

B. Campbell was commended for the success of her raffle of a print by Paul Harpley, the proceeds of which went to the Alfred Bog.

(d) *Study Groups*

F. Pope reported that interest in study groups had pretty much died out.

M. Stuart moved (2nd P. Martin) to accept the Report of Council.

(Motion Carried)

5. Nominations

D. Brunton, Chairman of the Nominations Committee, presented the following slate for the 1985 Council.

The Executive:

President	E. F. Pope
Vice-President	W. K. Gummer
Vice-President	W. R. Arthurs
Recording Secretary	B. J. Martin
Corresponding Secretary	A. M. Martell
Treasurer	P. D. M. Ward

Other Members of the Council:

R. E. Bedford	*G. Harrison
D. F. Brunton	V. B. Ladouceur
B. A. Campbell	L. S. Maltby
W. J. Cody	P. M. D. Martin
F. R. Cook	B. M. Marwood
E. M. Dickson	P. J. Narraway
*D. Fillman	K. W. Taylor
*A. Hackman	R. Taylor

*New Member of Council

D. Brunton moved (2nd E. Dickson) that the slate of nominations be approved.

(Motion Carried)

The President said a few words about each of the five retiring members of the Council and thanked them for their services. Retiring were:

S. Gawn
G. Hamre
D. Laubitz
C. Gruchy
J. Gillett

He then welcomed the three new members of the Council.

6. Nomination of Auditor

W. Cody moved (2nd D. Laubitz) that F. M. Brigham be appointed to audit the accounts of The Ottawa Field-Naturalists' Club for the 1984-85 fiscal year.

(Motion Carried)

7. New Business

(a) Club members were reminded that the Club has a new patron, Her Excellency, The Right Honorable Jeanne Sauvé.

(b) G. Christie informed members that the Society of Ottawa Nut Growers had a bumper crop of black walnuts this year. Anyone interested in growing a black walnut tree (Ottawa is on the northern edge of its range) should contact Christie.

8. Adjournment

D. Brunton moved (2nd E. Dickson) that the meeting be adjourned. Time: 21:55

(Motion Carried)

Following the business meeting a film entitled *The Rise and Fall of the Great Lakes* was shown. After the film, the group met for coffee.

B. J. MARTIN
Recording Secretary

Rare and Endangered Fishes and Marine Mammals of Canada: COSEWIC Fish and Marine Mammals Subcommittee Status Reports: II.

R. R. CAMPBELL

Resource Research Branch, Department of Fisheries and Oceans, 200 Kent St., Ottawa, Ontario K1A 0E6

Campbell, R. R. *Editor*. 1985. Rare and Endangered Fishes and Marine Mammals of Canada: COSEWIC Fish and Marine Mammals Subcommittee Status Reports: II. Canadian Field-Naturalist 99(3): 404–408.

The Fish and Marine Mammals Subcommittee of COSEWIC has prepared a further seven status reports for publication. Six of these are on marine mammals and one is on an anadromous fish of the Atlantic coast. This brings current the publication of fish and marine mammal reports on species assigned status by COSEWIC. Successes and future plans of the Subcommittee are discussed.

Le Sous-comité de poissons et de mammifères-marins du CSEFMEC a fait la critique de sept rapports de situation de plus pour publication. Six de ceux-ci sont sur les mammifères-marins et un de ceux-ci est sur un espèce du poisson anadrome de la côte du Atlantique. Ces rapports mettent en cours la publication des rapports de situation aux poissons et aux mammifères-marins pour les espèces qui ont reçu un statut par CSEFMEC. Le succès and les plans d'avenir du sous-comité sont discutés.

Key Words: endangered wildlife, fish, marine mammals, jeopardy.

As promised previously (Campbell 1984a) we are continuing the process initiated last year of publishing the status reports which the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) has used to assign status to species in jeopardy in Canada. This series of seven reports brings the Fish and Marine Mammals Subcommittee reports up-to-date as of April 1984 (see Table 1), the last general meeting. It is our intent to continue publication of the fish and marine mammal reports as these become available and status is assigned.

Current Progress

Previous articles have attempted to show the 'raison d'être' of COSEWIC (Campbell 1984a; Cook and Muir 1984), its organization and function, and that of one of the subcommittees (Fish and Marine Mammals). These articles sparked a great deal of interest in COSEWIC and in fishes and marine mammals thought to be in jeopardy in Canada. As a result of subsequent correspondence, the list of fishes for consideration has grown from 14 species (*see* Campbell 1984a: Table 3) to 46 species (Table 2). Similarly, marine mammals have been increased from 2 to 11 species. We currently have 40 status reports on fish species which are under review and 13 on marine mammals (Table 3). Some 12 to 14 of these will be presented for status assignment at the 1985 Annual meeting of COSEWIC and the remainder will be presented the following year.

Success?

What of the COSEWIC process? Are there positive concrete results? The St. Lawrence River Beluga report certainly stimulated a great deal of interest in the plight of these whales from which resulted public education programs, enforcement of the Beluga Protection Regulations of the Fisheries Act, and negotiation between the Province of Quebec and the Federal Government for the establishment of a sanctuary and/or marine park to protect critical habitat. Even though the Northern Quebec Beluga report has not been released, or status assigned to the population, the Department of Fisheries and Oceans has successfully encouraged Inuit hunters to reduce their harvest of the two concerned stocks as their population levels appear to be in decline. Efforts to save the Acadian Whitefish (Campbell 1984b) are also continuing.

In addition to such examples of direct action resulting from COSEWIC activity, there have been numerous less direct examples of our success. Several provinces and non-governmental agencies have produced poster series and other educational materials for public distribution and requests have been made of various members to participate in conferences and symposia (Campbell 1984b). As well, a cooperative funding mechanism is under discussion between the participating agencies to ensure the future of the organization. The response to the series of articles in *The Canadian Field-Naturalist* (1984, 98(1): 63–133) has also provided a positive reassurance of the value of our efforts.

Concluding Remarks

The following seven articles are reports on the status

TABLE 1. Fish and Marine Mammal Species with Assigned COSEWIC Status to March 1985.

Species	Scientific name	Status	Date assigned
Fish[1]			
Shortnose Sturgeon	*Acipenser brevirostrum*	Rare	April 1980
Spotted Gar	*Lepisosteus oculatus*	Rare	April 1983
Acadian Whitefish*	*Coregonus canadensis*	Endangered	April 1983
Silver Shiner	*Notropis photogenis*	Rare	April 1983
Speckled Dace	*Rhinichthys osculus*	Rare	April 1980
Spotted Sucker	*Minytrema melanops*	Rare	April 1983
River Redhorse	*Moxostoma carinatum*	Rare	April 1983
Giant Stickleback*	*Gasterosteus* sp.	Rare	April 1980
Charlotte Unarmoured Stickleback*	*Gasterosteus* sp.	Rare	April 1983
Shorthead Sculpin	*Cottus confusus*	Threatened	November 1983
Marine Mammals			
Sea Otter	*Enhydra lutris*	Endangered	May 1978
Blue Whale†	*Balaenoptera musculus*	Rare	April 1983
Bowhead Whale	*Balaena mysticetus*	Endangered	April 1980
Humpback Whale	*Megaptera novaeangliae*	Threatened	April 1982
Right Whale	*Eubalaena glacialis*	Endangered	April 1980
St. Lawrence River Beluga	*Delphinapterus leucas*	Endangered	April 1983

[1]The Blueback Herring (*Alosa aestivalis*) was investigated and found not to be in any COSEWIC category.
*Endemic to Canada
†Updated April 1984 — no status change.

TABLE 2. Fish and Marine Mammal Species of Interest to COSEWIC.

Species	Scientific Name	Possible Status
Fish		
Northern Brook Lamprey	*Ichthyomyzon fossor*	Rare
Chestnut Lamprey	*Ichthyomyzon castaneus*	Rare
Darktail Lamprey	*Lethenteron alaskense*	Rare
Bull Trout	*Salvelinus confluentus*	Rare in Alberta, but widespread in British Columbia
Bering Cisco	*Coregonus laurettae*	? (Yukon)
Lake Cisco	*Coregonus artedii*	Endangered in Lakes Erie and Ontario but widespread elsewhere
Lake Whitefish	*Coregonus clupeaformis*	Threatened in Lakes Erie and Ontario but widespread elsewhere
Mira Whitefish*	*Coregonus* sp.	Rare
Spring Cisco*	*Coregonus* sp.	Rare (Ontario and Quebec)
Pygmy Whitefish	*Prosopium coulteri*	Rare
Round Whitefish	*Prosopium cylindraceum*	Rare in Lakes Huron and Ontario but widespread elsewhere
Pygmy Longfin Smelt*	*Spirinchus thaleichthys*	Rare (landlocked population in Harington Lake, British Columbia); anadromous populations are widespread
Redfin Pickerel	*Esox americanus americanus*	Rare
Grass Pickerel	*Esox americanus vermiculatus*	Rare
Bluntnose Minnow	*Pimephales notatus*	Rare (Manitoba)
Eastern Silvery Minnow	*Hybognathus nuchalis regius*	Rare
Western Silvery Minnow	*Hybognathus argyritis*	?
Hornyhead Chub	*Nocomis biguttatus*	?Rare
River Chub	*Nocomis micropogon*	Rare
Redfin Shiner	*Notropis umbratilis*	Rare
Nooky Dace	*Rhinichthys cataractae* ssp.	Rare
Leopard Dace	*Rhinichthys falcatus*	Rare
Liard Hotspring Lake Chub*	*Couesius plumbeus*	Rare (Liard Hotspring, British Columbia); other populations of the species are widespread

TABLE 2. *(concluded)*

Species	Scientific Name	Possible Status
Mountain Sucker	*Catostomus platyrhynchus*	Rare
Lake Chubsucker	*Erimyzon sucetta*	Rare
Bigmouth Buffalo	*Ictiobus cyprinellus*	Rare
Golden Redhorse	*Moxostoma erythrurum*	Rare
Black Bullhead	*Ictalurus melas*	Rare
Banded Killifish	*Fundulus diaphanus*	Rare in Newfoundland and Manitoba, widespread elsewhere
Brook Silverside	*Labidesthes sicculus*	?
Texada Stickleback*	*Gasterosteus* sp.	Rare
Redbreast Sunfish	*Lepomis auritus*	Rare (New Brunswick)
Eastern Sand Darter	*Ammocrypta pellucida*	Rare
Greenside Darter	*Etheostoma blennioides*	Rare
Least Darter	*Etheostoma microperca*	?
Channel Darter	*Percina copelandi*	Rare
River Darter	*Percina shumardi*	Rare
Y-Prickleback	*Allolumpenus hypochromus*	Rare (British Columbia)
Striped Bass	*Morone saxatilis*	Endangered (Quebec)
Cultus Pygmy Sculpin*	*Cottus aleuticus*	Threatened
Spinynose Sculpin	*Asemichthys taylori*	Rare (British Columbia)
Pixy Poacher*	*Occella impi*	Rare (British Columbia)
Bering Wolffish	*Anarhichas orientalis*	Rare
Blackline Prickleback	*Acantholumpenus mackayi*	Rare
Bluefin Tuna	*Thunnus thynnus thynnus*	?Threatened
Pacific Sardine	*Sardinops sagax caerula*	Rare
Marine Molluscs		
Northern Abalone	*Haliotis kamtschatkana*	?
Marine Mammals		
Steller's Sea Lion	*Eumetopias jubatus*	Rare
Baird's Beaked Whale	*Berardius bairdii*	?
Northern Bottlenose Whale	*Hyperoodon ampullatus*	?
Atlantic Grey Whale	*Eschrichtius robustus*	Extirpated
Sei Whale	*Balaenoptera borealis*	Rare (North Atlantic)
Minke Whale	*Balaenoptera acutorostrata*	?Rare
Sperm Whale	*Physeter macrocephalis*	?N.I.A.C.
Stejneger's Beaked Whale	*Mesoplodon stejnegeri*	Rare
Hubb's Beaked Whale	*Mesoplodon carlhubbsi*	Rare
Dall's Porpoise	*Phocoenoides dalli*	Rare
Longfinned Pilot Whale	*Globicephala melaena*	?

*Endemic to Canada

of marine mammals which have come to COSEWIC's attention and have been assigned an official COSEWIC status. The reports are much the same as originally produced by the author with some minor editing to give some degree of commonality in form and presentation. Brief introductions have been added. They are published under the name of the original author.[1]

The status report on the Blueback Herring has been included, even though the species was found not to be in jeopardy, because it was a solicited report and was considered by the Committee. It is reassuring to find from time to time that a species thought to be in jeopardy actually is not. This is all part of the process and serves as a reminder that public interest does exist, even for those species which may not be "attractive attention getters".

It is hoped that we will be able to continue this process each year and that eventually all status reports

[1]Because of time restraints however, most have not been reread in this form by these authors, nor has there been an opportunity for authors to update them. The acceptance date of the original report by COSEWIC is indicated for each.

including those for birds, plants, mammals, reptiles and amphibians will be published as well.

Acknowledgments

I would like to acknowledge the authors of these reports for their efforts and interest in COSEWIC and the Publication Committee of this journal for their consideration and cooperation. The efforts of all members of the Fish and Marine Mammals Subcommittee (*see* Campbell 1984a) in reviewing reports and for helpful suggestions has been greatly appreciated. I would also like to thank all those other numerous unnamed individuals whose support and interest has helped to make the process successful. Thanks are also due M. Guruprasod for her work in typing the manuscripts and unstinting efforts with the correspondence, files, etc.

TABLE 3. Fish and Marine Mammal Species for which Status Reports are in preparation, or under review — January 1985.

Species	Scientific Name	Proposed Status
Fish		
Lake Lamprey*	*Lampetra macrostoma*	?
Paddlefish	*Polyodon spathula*	Extirpated
Atlantic Sturgeon	*Acipenser oxyrhynchus*	?
Green Sturgeon	*Acipenser medirostris*	Rare
Lake Sturgeon	*Acipenser fulvescens*	N.I.A.C.
White Sturgeon	*Acipenser transmontanus*	?
Aurora Char*	*Salvelinus fontinalis timagamiensis*	Extirpated
Blackfin Cisco	*Coregonus nigripinnis*	Threatened
Bloater	*Coregonus hoyi*	Rare
Deepwater Cisco	*Coregonus johannae*	Endangered
Kiyi	*Coregonus kiyi*	Rare
Simcoe Lake Whitefish	*Coregonus* sp.	?
Longjaw Cisco[1]	*Coregonus alpenae*	Extinct
Opeongo Whitefish*	*Coregonus* sp.	Threatened
Shortnose Cisco	*Coregonus reighardi*	Threatened
Shortjaw Cisco	*Coregonus zenithicus*	Extinct (Lakes Huron, Erie and Ontario)
Squanga Whitefish*	*Coregonus* sp.	Threatened
Pygmy Smelt	*Osmerus spectrum*	Rare
Banff Longnose Dace*	*Rhinichthys cataractae smithi*	Endangered
Redside Dace[1]	*Clinostomus elongatus*	Threatened
Umatillus Dace	*Rhinichthys umatillus* spp.	? (Two forms — Otter Creek & Kettle River, British Columbia)
Silver Chub[1]	*Hybopsis storeriana*	Rare
Gravel Chub[1]	*Hybopsis x-punctata*	Extirpated
Pugnose Minnow[1]	*Notropis emiliae*	Endangered
Bigmouth Shiner[1]	*Notropis dorsalis*	Rare
Pugnose Shiner[1]	*Notropis anogenus*	Rare
Silver Shiner	*Notropis photogenis*	Rare†
Central Stoneroller[1]	*Campostoma anomalum*	Rare
Blackstripe Topminnow[1]	*Fundulus notatus*	Endangered
Campbell Sucker	*Catostomus sp.*	Endangered
Jasper Longnose Sucker*	*Catostomus catostomus lacustris*	Rare
Black Redhorse	*Moxostoma duquesnei*	Endangered
Copper Redhorse	*Moxostoma hubbsi*	Threatened
River Redhorse	*Moxostoma carinatum*	Rare†
Brindled Madtom[1]	*Noturus miurus*	Endangered
Green Sunfish	*Lepomis cyanellus*	Rare
Longear Sunfish	*Lepomis megalotis*	Rare
Blue Walleye[1]	*Stizostedion vitreum glaucum*	Extinct
Deepwater Sculpin	*Myoxocephalus thompsoni*	Extirpated in Lake Ontario and ? in Lake Erie; widespread elsewhere
Enos Lake Stickleback*	*Catostomus* sp.	Threatened (British Columbia)
Marine Mammals		
Foxe Basin Walrus	*Odobenus rosmarus*	?
Cumberland Sound Beluga	*Delphinapterus leucas*	?

TABLE 3. *(concluded)*

Species	Scientific Name	Proposed Status
McKenzie Bay Beluga[1]	*Delphinapterus leucas*	Common
Northern Québec Beluga	*Delphinapterus leucas*	Endangered
Bowhead Whale	*Blaena mysticetus*	Endangered†
Fin Whale	*Balaenoptera physalus*	Rare
Humpback Whale[1]	*Megaptera novaeangliae*	Threatened†
Narwhal	*Monodon monoceros*	?
Right Whale[1]	*Eubalaena glacialis*	Endangered†
Sea Otter	*Enhydra lutris*	Endangered†
Northern Elephant Seal	*Mirounga angustirostris*	N.I.A.C.
Hooded Seal	*Cystophora cristata*	N.I.A.C.

[1]Submitted for 1984/85 General Meeting
*Endemic to Canada
†Status as indicated already assigned (see Table 1). These are updated status reports.

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Received 12 March 1985
Accepted 12 March 1985

Status of the Blueback Herring, *Alosa aestivalis*, in Canada*

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Dadswell, M. J. 1985. Status of the Blueback Herring, *Alosa aestivalis*, in Canada. Canadian Field-Naturalist 99(3): 409–412.

Blueback Herring populations occur in all the larger drainage basins of New Brunswick and Nova Scotia. Population estimates using run composition data indicate Bluebacks compose 20–50% of most "alewife" runs with numbers of adults of up to 5 million in the Saint John River and 1–2 million in the Miramichi River. Available data from the Saint John River indicate that in recent years, the number of Blueback Herring has increased.

Les populations d'aloses d'été, *Alosa aestivalis*, se rencontrent dans tous les bassins hydrographiques importants du Nouveau-Brunswick et de la Nouvelle-Ecosse. Les estimation des populations faites à l'aide des données sur la composition des montaisons indiquent que les aloses d'été représentent 20 à 50% de la plupart des montaisons de gaspareaux et comptent jusqu'à 5 millions d'adultes dans la rivière Saint-Jean et 1 à 2 milions d'adultes dans la rivière Miramichi. Les données disponibles pour la rivière Saint-Jean révèlent que le nombre d'aloses d'été a augmenté au cours des dernières années. [Traduit par R. R. Campell].

Key Words: herring, *Alosa aestivalis*, alewives, *Alosa pseudoharengus*, New Brunswick, Nova Scotia, distribution, population size and trends.

The Blueback Herring (*Alosa aestivalis*) is a small anadromous fish that may be found in many of the rivers of the east coast, south from the Miramichi in New Brunswick and throughout Nova Scotia. In appearance (Figure 1) it is similar to the Alewife (*Alosa pseudoharengus*) but has dark blue to bluish gray colour on the back where the Alewife is more green. The most reliable distinguishing feature is the black peritoneum of the Blueback in contrast to the pearl or pinkish-gray peritoneum of the Alewife. Both species are silvery on the sides and bottom (Leim and Scott 1966). The body is deep, compressed and elongated with a forked caudal fin. They seldom exceed 5.5 cm in length and are more usually 3.9-4.7 cm in length.

Distribution

Blueback Herring occur along the east coast of North America from northern Florida to the Miramichi River, New Brunswick (Figure 2; Bigelow and Schroeder 1953; Leim and Scott 1966). Throughout this range they are very abundant in most small and large rivers that have free access to the sea. They occur offshore as far as 200 km (Bigelow and Schroeder 1953; Netzel and Stanek 1966) and probably undertake similar winter-summer, offshore-onshore migrations as do shad (Neves and Depres 1979).

Protection

The Fisheries Act of Canada of 1867 requires protection and management of all commercial fish species. The Amendment of the Act of 1976 provides for habitat protection of all commercial fish species.

Population sizes are not mentioned in the Fisheries Act as catch statistics have not distinguished between Blueback Herring and Alewife until recent years. No subspecies of Blueback Herring have been described. The wide distribution of this species while in the sea and its semi-pelagic nature have provided protection from the effects of overfishing juvenile fish.

Population Size and Trends

The absolute number of Blueback Herring in Canada is presently unknown. Escapement and commercial catch of Bluebacks and Alewives in the Saint John River, New Brunswick, for the period 1967-1978, are summarized in Table 1 (Reid 1978). Population size would appear to be from 2-5 million adult Bluebacks during that period. Run composition data from the Miramichi, Shubenacadie and Margaree Rivers (Table 2) indicates population levels in each of these rivers may be from 200 000 to 1+ million adult Bluebacks. In aggregate, Blueback Herring populations in the Maritimes may fluctuate between 3 and 8 million adults a year, with a corresponding greater number of juveniles present in the sea. Data from the Saint John River indicates the Blueback populations in that river may be increasing at present, but this trend may also be a reflection of more accurate species determination within "Alewife" landings in recent years.

*Reviewed by COSEWIC, April 1980 and found not to be in any COSEWIC category (N.I.A.C.).

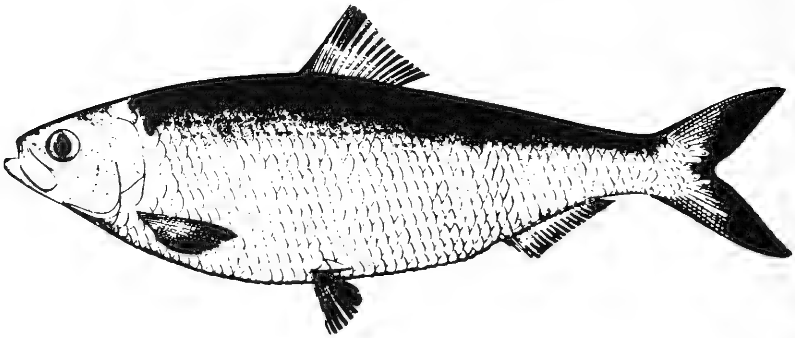

FIGURE 1. The Blueback Herring *Alosa aestivalis.*

Habitat

Blueback Herring breed in streams along the North American Altantic coast in regions of fast-flowing water with associated hard substrate (Loesch and Lund 1977). In the Maritimes, these conditions are met in almost all coastal streams not obstructed by natural or man-made structures. Breeding populations are known from Nova Scotia and New Brunswick and probably occur in Prince Edward Island. With the demise of most small man-made structures on Maritime watercourses since the decline of water mills and the movement of logs by water, it seems likely that the spawning habitat available to Blueback Herring has increased during this century. Many obstacles still exist, however, and the Maritime populations could still increase.

Blueback Herring are seldom observed in the sea. Sporadic trawl catches occur, mainly in the region of the 50-fathom line of the Continental Shelf between Georges Bank and New Jersey (Bigelow and Schroeder 1953; Netzel and Stanek 1966).

General Biology

The Blueback Herring makes its growth in salt water, but runs into fresh water to spawn. Breeding occurs in regions of fast stream flow with hard substrate. Spawning occurs in spring at water temperatures of 14 to 24° C, but tends to peak in intensity at 20 to 22° C, or during late June-early July in the Maritimes (Messieh 1977). The Bluebacks spawn somewhat later than the Alewives (Leim and Scott 1966) and the characteristics of eggs, growth and feeding are thought to be similar. Leim and Scott (1966) provided the following source for biological data on Alewives

TABLE 1. Saint John River, New Brunswick escapement and commerial harvest of Alewives and Blueback Herring*

	Mactaquac Fish Lift					Total Saint John River Commercial
	Spawning Escapement		Commercial			
Year	Alewife (No. of fish)	Blueback (No. of fish)	Alewife (No. of fish)	Blueback (No. of fish)	Weight Metric Tons	Weight (Metric Tons)
1967	Dam Constr.					
1968	20 100	1 900				
1969	92 800	13 500				
1970	70 400	14 100				
1971	313 200	81,300				
1972	848 000	365 500				
1973	1 158 000	268 600				
1974	597 300	136 100	543 100	65 100	156.709	3 134.176
1975	783 400	174 700	1 326 400	200 200	322.237	1 910.616
1976	615 100	160 600	1 743 300	918 000	571.794	2 020.935
1977	299 300	185 300	2 692 300	1 036 500	876.899	2 450.768
1978	450 000	550 000 (est.)	3 356 100	3 542 550 (est.)		

*Statistics, Districts 48, 49, 44–58, Fisheries and Marine Service, Halifax.

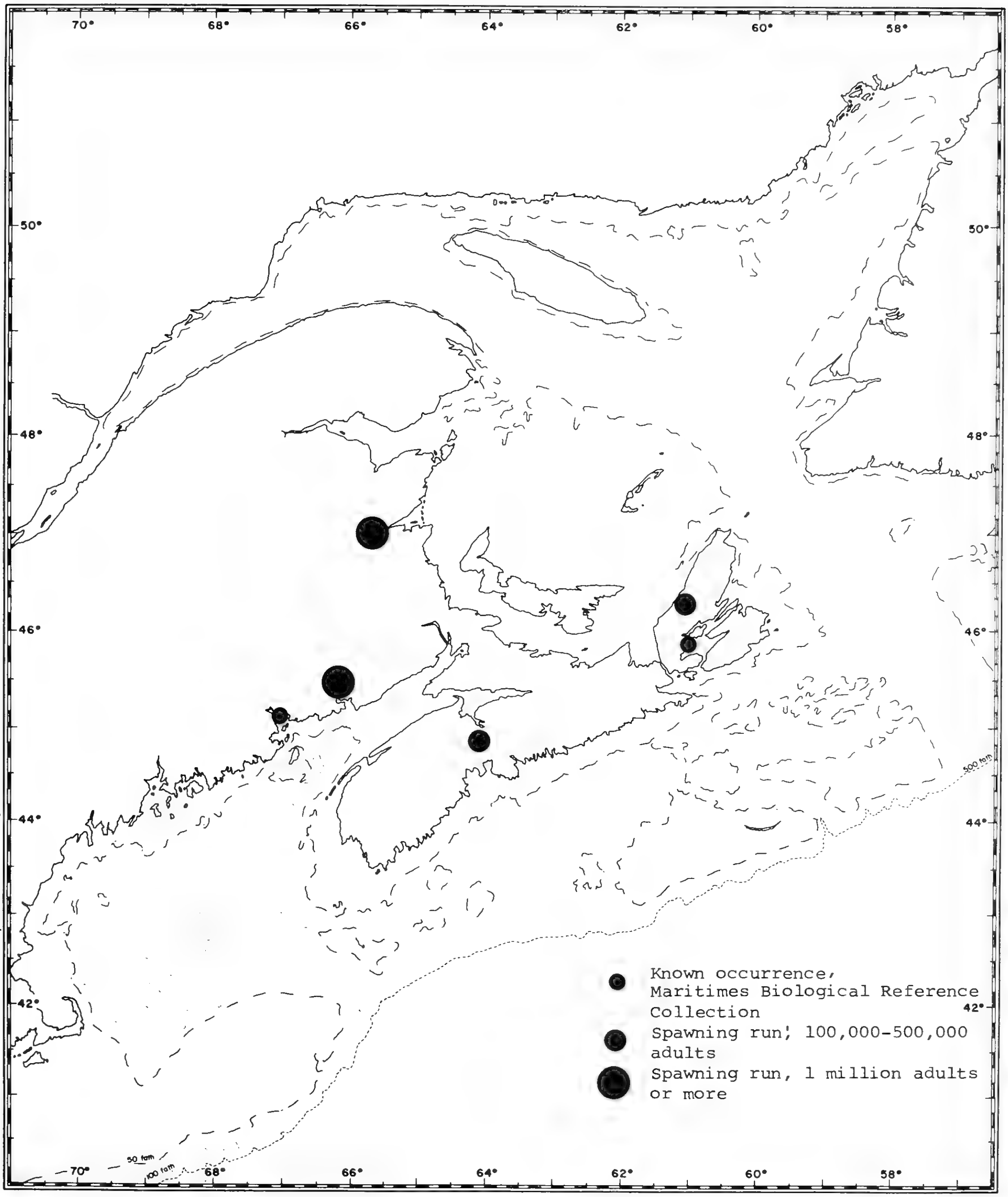

FIGURE 2. Distribution records for the Blueback Herring, *Alosa aestivalus*, in the Maritime Provinces of Canada.

TABLE 2. Run composition, mean commercial catch and estimated population of Blueback Herring in Maritime Rivers

River	Run composition Blueback Herring %	Alewife, 1970–80 mean catch (lbs) × 10^3	Population Estimated size × 10^3
Miramichi	53	2012.0	2000.0
Subenacadie	42	393.0	350.0
Margaree	17	2310.0	800.0

of the Atlantic. Females probably produce 60-100 000 eggs, each about 1.3 mm in diameter, which are scattered over a gravel bottom where they adhere to sticks, stones, gravel and other debris. Hatching requires 3-6 days at 15°-17.2°C. Spent fish return to the sea. The fry are very small (3 mm), but growth is rapid and by August or September when they move to the sea, may average 5 cm. The juveniles mature in 3 to 4 years at about 19-20 cm. Females are usually larger than males.

The food of the Blueback Herring is almost certainly similar to that of the Alewife which feeds chiefly on plankton. Amphipods, mysids, copepods; small fish and fish eggs, may also be important in the diet (Leim and Scott 1966).

Little is known of their parasites. Bluebacks are an important forage species to seals, eels and many larger species of fish.

Limiting Factors

The limiting factor for Blueback Herring is probably the availability of unpolluted, unobstructed spawning streams. At present, availability of such sites in the Maritimes is relatively high. Man-made obstruction of coastal streams in the Maritimes has declined during this century and severe blockage problems now exist mainly in the rivers of the Upper Bay of Fundy.

Special Significance of the Species

No government or individual has attached special significance to the Blueback Herring. In fact, until recently, it was lumped with "Alewives" in the commercial landing statistics and was a poorly-known species. The species does, however, contribute significantly to the river herring landings in the Maritimes at a level of 3–5 million pounds or $200 000 a year.

Evaluation

It appears there is an abundance of Blueback Herring, widely spread along the Canadian Atlantic coast. Populations appear to be stable and/or increasing. Management and stream rehabilitation programs should be undertaken to increase the abundance of the species, and its yield to our commercial fishery. The species cannot be considered rare, threatened, or endangered in Canada.

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Status of the Sea Otter, *Enhydra lutris*, in Canada*

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Munro, Wm. T. 1985. Status of the Sea Otter, *Enhydra lutris*, in Canada. Canadian Field-Naturalist 99(3): 413–416.

Historically, the Sea Otter was a common animal on the West Coast of Canada. Its decline began shortly after Captain James Cook arrived at Nootka Sound on Vancouver Island in 1778. Trade in furs so reduced the Sea Otter population that by 1830, they were almost extinct. An international Treaty providing protection for Sea Otters was finally concluded in 1911. The last documented record of a Sea Otter in British Columbia was 1929. A small population has survived in California, but most remaining Sea Otters occur in Alaska. By the late 1960's the Alaska population had recovered to some 30 000 animals. Because Sea Otter habitat is plentiful in British Columbia, plans were made to transplant animals from Alaska. Between 1969 and 1972, 89 animals were released on the northwest coast of Vancouver Island. Sporadic sightings have been made since the introductions, but the first significant sightings were made by staff of Fisheries and Oceans in 1977 when two groups of Sea Otters, 55 and 15 individuals, with young, were observed. While the Sea Otter must still be considered endangered in Canada, one can now be optimistic about its chances for recovery.

Anciennement, la loutre de mer était un animal commun sur la côte ouest du Canada. Le déclin de l'espèce s'amorça peu après l'arrivée du capitaine James Cook à l'île Vancouver, par la baie Nootka, en 1778. Le commerce des fourrures réduisit la population de loutres de mer à tel point que l'espèce était presque disparue en 1830. Un traité international assurant la protection des loutres de mer finit par être conclu en 1911. Avant la réintroduction de l'espèce, la présence de la loutre de mer en Colombie-Britannique fut signalée pour la dernière fois en 1929. Une petite population a survécu en Californie, mais la plupart des loutres de mer se trouvent en Alaska. A la fin des années 1960, la population de l'Alaska s'était rétablie et se chiffrait à quelque 30 000 bêtes. Vu la richesse de l'habitat de la loutre de mer en Colombie-Britannique, on élabora des plans pour y transplanter des bêtes provenant de l'Alaska. Entre 1969 et 1972, 89 loutres étaient libérées sur la côtes nord-ouest de l'île Vancouver. Après leur réintroduction, des loutres furent aperçues sporadiquement, mais les premières observations importantes remontent à 1977 : le personnel de Pêches et Environment Canada observa alors deux groupes de 55 et 15 loutres de mer, parmi lesquelles se trouvaient des petits. Bien que la loutre de mer soit encore considérée comme une espèce menacée d'extinction au Canada, on peut maintenant être optimiste quant à ses chances de rétablissement. [Traduit par R. R. Campbell]

Key Words: Sea Otters, *Enhydra lutris*, British Columbia, population size and trends, marine mammals.

The Sea Otter (*Enhydra lutris*) is a 1.5 m long, 28 kg furry mammal (Figure 1). It is the largest of the weasel family in Canada and resembles the more common River Otter (*Lutra canadensis*). They are found only in or near salt water usually in shallow exposed coastal areas where the shellfish and sea urchins, on which they feed, are plentiful. These are obtained by diving in water 2 to 15 metres deep. Upon surfacing, the otters roll on their backs, place the food on their chests and eat it bit-by-bit. Because their hind legs are largely flippers, Sea Otters are very awkward on land. They seldom come ashore and usually sleep in off-shore kelp beds with the kelp twisted around them to keep them from drifting away. Because the Sea Otter depends on its fur rather than its blubber for protection from cold, it is extremely susceptible to oil pollution. Many of its waking hours are devoted to cleaning its fur.

Distribution

The Sea Otter was formerly distributed from California north through the Aleutian Islands to the Kamchatka Peninsula in Russia and the northern islands of Japan. It probably occurred along the entire outer British Columbia coast, especially along Vancouver Island and the Queen Charlotte Islands (Blood 1967). Massive exploitation for its fur in the late eighteenth and nineteenth centuries almost caused its extinction. Small populations remained in the late nineteenth century in California, British Columbia, Alaska, and Russia. The last known occurrence of Sea Otter in British Columbia was of one illegally killed near Kyuquot in 1929 (Blood 1967). The present distribution of the Sea Otter in North America is central California, the Aleutian Islands, the Alaska Peninsula and, as a result of transplants (Mackaskie 1971), some islands in southeast Alaska, Vancouver Island, B.C., Washington and Oregon. For details of former and present distribution see Figure 2.

Protection

Protection was first extended to the Sea Otter in

Endangered status approved and assigned by COSEWIC 2 May 1978.

1911 with the signature of an international treaty by the United States, Russia, Japan and Great Britain (Canada). Sea Otters are protected in British Columbia by the Federal Fisheries Act and the B.C. Wildlife Act and Regulations.

Population Size and Trends

Sea Otters were re-introduced to the northwest coast of Vancouver Island by the British Columbia Fish and Wildlife Branch and the Fisheries Research Board of Canada in 1969, 1970, and 1972. A total of 89 animals were released. Sporadic sightings have been reported since the first release, but the first significant sightings were made in the summer of 1977, by staff from the Department of Fisheries and Oceans, at the Pacific Biological Station, Nanaimo, British Columbia. During an aerial survey of the west coast of Vancouver Island they spotted 70 Sea Otters, including young, in two groups. Based on experience with transplanted colonies of about the same size in Alaska, this colony should increase at a rate of at least 10% annually.

Habitat

Much of the outer west coast of Vancouver Island, the mainland coast north of Vancouver Island and the Queen Charlotte Islands offers suitable Sea Otter habitat (Kenyon 1967). There is no information to suggest that the quantity or quality of Sea Otter habitat has been significantly reduced from historical times. Increases in oil pollution, boat traffic and commercial exploitation of shellfish or kelp could decrease the quality of habitat.

Sea Otter habitat is composed of two major items, shallow exposed coastal areas and a plentiful supply of shellfish and sea urchins. Most Sea Otter habitat, both shoreline and ocean is Crown owned. Land habitat is not protected as many activities are permitted on Crown lands. However, given the remoteness of much of the habitat and the generally non-conflicting other uses at present, protection is judged adequate. As the population expands and concentration areas are determined consideration could be given to their designation as Wildlife Management Areas. The sea habitat, shellfish and kelp beds near storm protected waters, appears to be adequately protected at this time from all but oil pollution.

General Biology

Sea Otters probably do not breed until 3 years of age. Females have one young every two years and there is no set season for birth. Longevity is unknown, but they probably live for 15 to 20 years (Kenyon 1967).

Predators are few and include the Killer Whale (*Orcinus orca*) and sharks. Net recruitment rate in Alaska is estimated to be at least 10% per annum for Sea Otters in new habitat (Vania 1968; Anonymous 1977). The reproductive rate of the transplanted British Columbia population is unknown, but in 1977, some young were seen in a total of 70 animals [one young per four adults is probable — at least for Alaska (Vania 1968; Anonymous 1977)].

Sea Otters are generally sedentary and usually do not travel far unless food is in short supply.

The colonies in British Columbia are located in remote areas. It is to be expected that they would not be unduly disturbed by the casual presence of people. Sea Otters are specialized in their food to the extent that they require sea urchins and shellfish. They require shallow water (two to fifteen metres) as they dive to the bottom to capture food, surface and roll on their backs, place the food on their chest and eat it bit-by-bit.

Because the Sea Otter depends on its fur for protection from cold, rather than blubber as in most marine mammals, it is extremely susceptible to oil pollution. Oil quickly destroys the insulating quality of its fur and the animal then dies of exposure.

Limiting Factors

Commercial over-harvest caused the extirpation of the Sea Otter in British Columbia. Under total protection we can identify no limiting factor that is likely to keep the Sea Otter population from expanding. Eventually food supply or some other factor will limit numbers in local areas, but there is, at present, much vacant habitat that can be used.

Special Significance of the Species

The Sea Otter is plentiful in Alaska. There are also populations of variable sizes in California and Russia. Re-introductions have been made in Oregon, Washington and British Columbia. Populations in British Columbia are not critical to the survival of the species in North America or the world. Survival in British Columbia is important in Canada, however, as it is the only area where they were historically present. The Sea Otter is of public interest because of its significance in the early history of British Columbia, its pleasing (to humans) behaviour, and because man was solely responsible for its extirpation in Canada.

Evaluation

The Sea Otter population disappeared due to overharvest for commercial purposes in historical times. The species, as demonstrated in Alaska and California, is capable of making a comeback given protec-

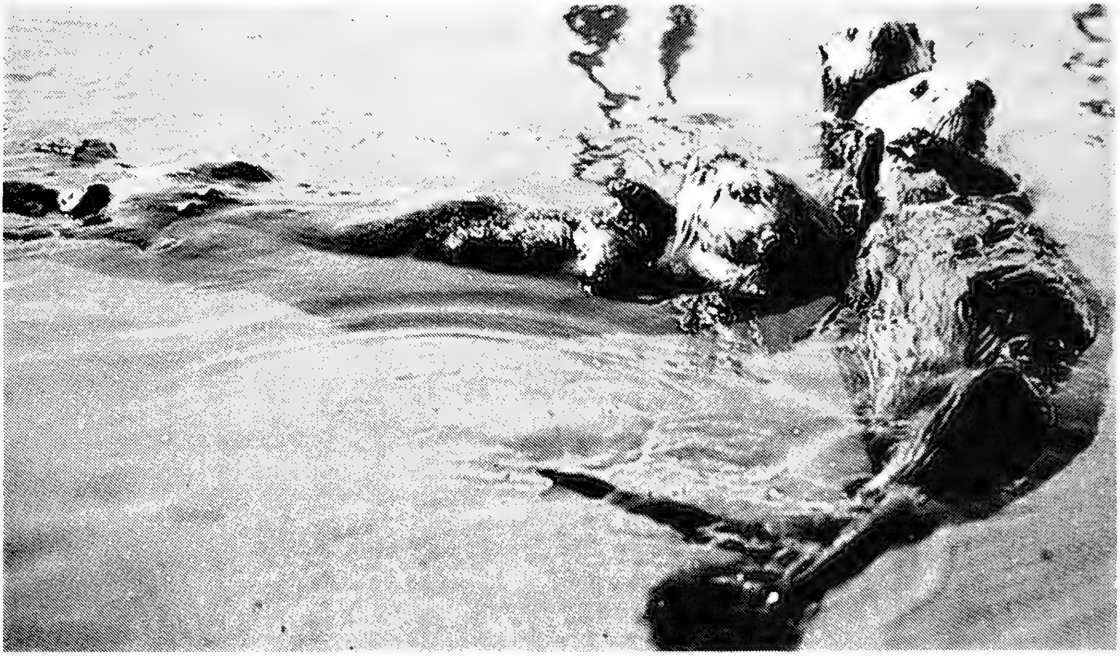

FIGURE 1. Sea Otter, *Enhydra lutris* (Courtesy B. Smith, British Columbia Fish and Wildlife Branch).

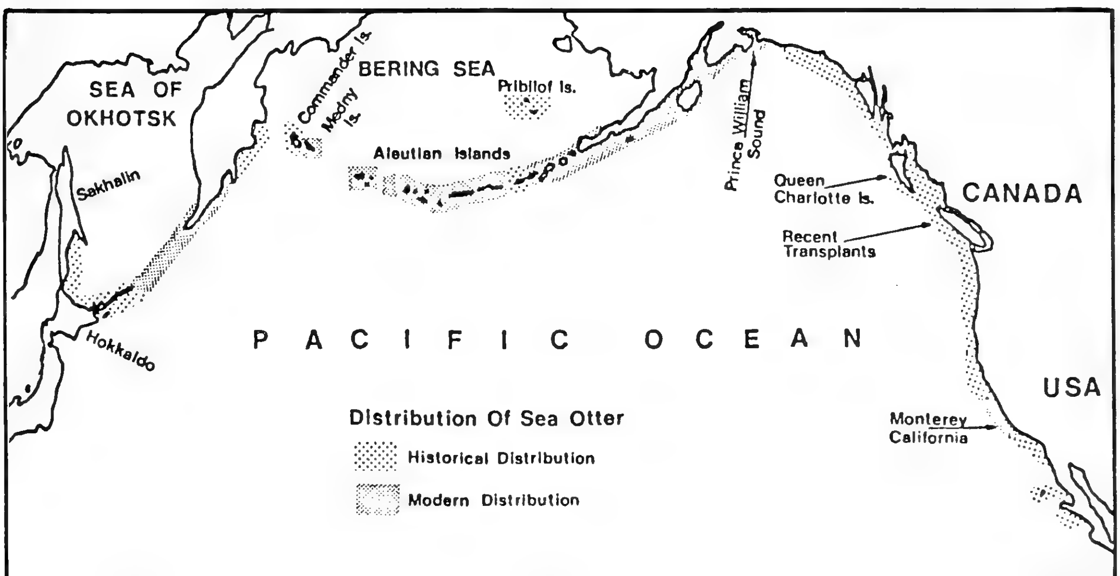

FIGURE 2. Current and historical world distributions of the Sea Otter, *Enhydra lutris*.

tion. The population in British Columbia appears viable and is expected to gradually increase in number and range. Barring large scale oil spills, one can be optimistic about its future in British Columbia.

Acknowledgments

This report was coordinated through the British Columbia Fish and Wildlife Branch of the British Columbia Ministry of the Environment. I would like to thank M. A. Bigg, Fisheries and Oceans Canada, Pacific Biological Station, Nanaimo, B. C., and C. J. Guiguet, B. C. Provincial Museum, Victoria, for their cooperation and assistance in preparation of the manuscript.

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Status of the Blue Whale, *Balaenoptera musculus,* in Canada*

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The Blue Whale occurs off the coast of British Columbia and in most of the coastal waters of eastern Canada, including the Gulf of St. Lawrence. The eastern Pacific stock was hunted in small numbers from land stations in Canada, but most reduction in this population probably occurred in Alaskan waters at the northern limit of migration. The Atlantic stock was reduced by commercial whaling carried out from land stations and pelagic factory ships during the first half of the 20th century. The Pacific stock has been protected since 1966 and the Atlantic stock since 1955.

On trouve la rorqual bleu au large des côtes de la Colombie-Britannique et dans la plupart des eaux côtières de l'Est du Canada, y compris le golfe Saint-Laurent. Le stock du Pacifique oriental était chassé au Canada de façon limitée à partir de stations terrestres, mais la réduction de cette population est probablement liée surtout à l'activité menée dans les eaux de l'Alaska à sa limite septentrionale de migration. Le stock de l'Atlantique a été décimé par la chasse commercial menée pendant la première moitié du 20e siècle à partir de stations terrestres et de navires-usines hauturiers. Le stock du Pacifique est protégé depuis 1966, celui de l'Atlantique depuis 1955. [Traduit par R. R. Campbell]

Key Words: baleen whales, Blue Whale, *Balaenoptera musculus,* Atlantic whales, Pacific whales, large whales.

The Blue Whale (*Balaenoptera musculus*) is the largest of all animals averaging 23-32 m in length and weighing 80-130 tonnes (Figure 1). The calves are about 7 m at birth and weigh approximately 7 tonnes (Watson 1981). Blue Whales derive their name from their overall colour, marine blue-gray which may be mottled with light gray or white. The flipper tips and undersides are much lighter. Blue Whales are often commonly called 'sulphur bottom' due to a film of yellow-green diatoms which may conceal the natural colour. These whales are long and streamlined with a very small dorsal fin located well posterior and with relatively short flippers. There are numerous grooves on the throat which extend beyond the navel.

Blue Whales are found in most of the world's oceans, but are now less numerous than prior to commercial whaling, although they probably never occurred in large numbers (Watson 1981). The whales travel in close-knit groups of 3-4 animals, but at times may congregate in larger groups. They feed on swarming planktonic forms in shallow northern waters and migrate towards the equator after the ice pack covers the feeding areas.

Distribution

Atlantic: occurs in spring, summer and fall in the Gulf of St. Lawrence, especially along the north shore from the estuary to the Strait of Belle Isle, and off eastern Nova Scotia and in winter off Southern Newfoundland (Figure 2). Also found in summer in Davis Strait. Before protection from land-based commercial whaling in 1955, catches were made in the northern Gulf of St. Lawrence and the Strait of Belle Isle, and in southern Newfoundland where whaling ceased in 1944 (Sergeant 1953, 1966; True 1904). The stock in the Gulf of St. Lawrence may be discrete (Mitchell 1975).

Pacific: Rice (1974) postulates that the Canadian stock leaves Baja, California in May and arrives off Vancouver Island in June. From there, some migrate to the eastern Aleutians or into the Gulf of Alaska. They pass Vancouver Island again in September on the way south.

Protection

International: all stocks are listed as protected by the International Whaling Commission. In the North Atlantic, pelagic factory-ship whaling for this species has been prohibited since 1938, and shore-based whaling since 1955. In the North Pacific both pelagic and shore-based hunting of Blue Whales have been prohibited since 1966 (International Whaling Commission 1967). They are protected from international trade by listing on Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

National: protected by Canadian Whaling Regulations (Canada Department of Fisheries and Oceans 1979) which prohibit commercial whaling within Canada's 200 mile fisheries zone.

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*Rare status approved and assigned by COSEWIC 6 April 1983. Updated April 1984.

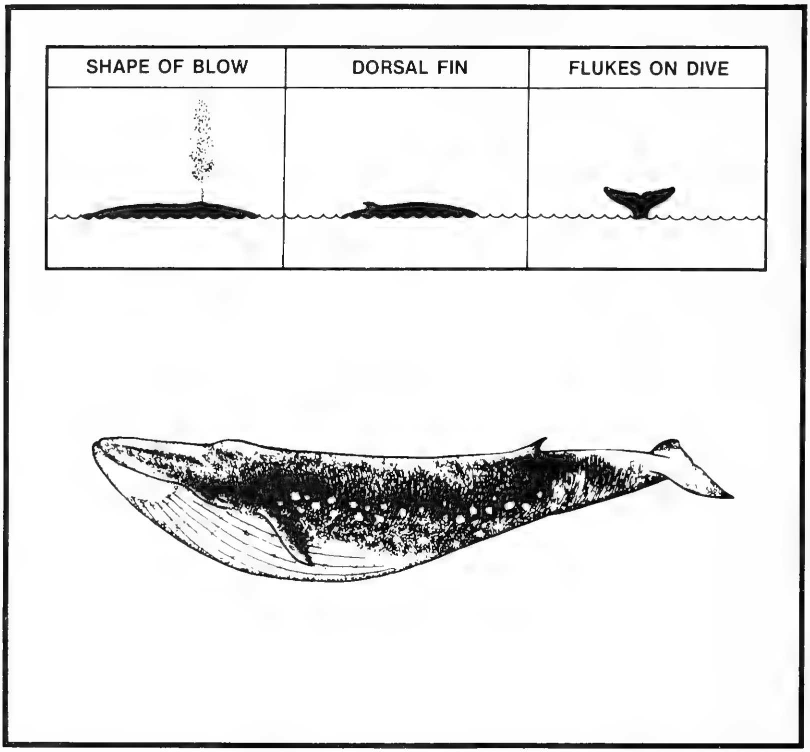

FIGURE 1. The Blue Whale, *Balaenoptera musculus*.

Population Size and Trend

Atlantic: Quantitative information on the Northwestern Atlantic population is sparse, but Sergeant (1966) estimated a virgin stock of about 1500 from the cumulative catch in the early whaling period (1898-1915). Present estimates, based upon strip censuses, are in the very low hundreds (Mitchell 1974). There may be 60-100 Blue Whales in the Gulf of St. Lawrence (D. E. Sergeant personal communication), but there are no current studies on the populations south of Newfoundland and off Nova Scotia, and on their relationship to the animals in the Gulf. The relationships of present populations to past abundance are unknown, except that the areas of occurrence are the same (D. E. Sergeant personal communication). A series of recent strandings in southwestern Newfoundland (Mitchell 1974, 1978, 1979; D. E. Sergeant, personal communication) suggests that the numbers may be increasing in the Gulf of St. Lawrence.

North Pacific: During the period 1913-1965, Blue Whale catches from land stations in British Columbia averaged about 14 per year, with a maximum of 62 in 1923 (Pike and MacAskie 1969). The population was estimated to be 600 in 1952, and 1400 by 1964 (International Whaling Commission 1967). From total catches in the eastern North Pacific in the period 1924-1929, Rice (1974) estimated the stock at that time to be about 6 000. His data suggested "that Blue Whales were never very abundant in the eastern North Pacific and their population has not decreased very markedly." Gamble (1976) reports that the exploitable portion of the stock numbered 4 900 prior to whaling and 1 600 after. The total population is perhaps 1.5-2.5 times larger than the exploitable population.

Habitat

According to Pike and MacAskie (1970), Blue Whales off the west coast of Canada seldom enter marginal or inland seas, but are usually found well offshore. In eastern Canada, they are found in regions of the estuary and the Gulf of St. Lawrence and in the shallow coastal zones of Newfoundland, where mixing of bottom and surface waters results in a high productivity of plankton.

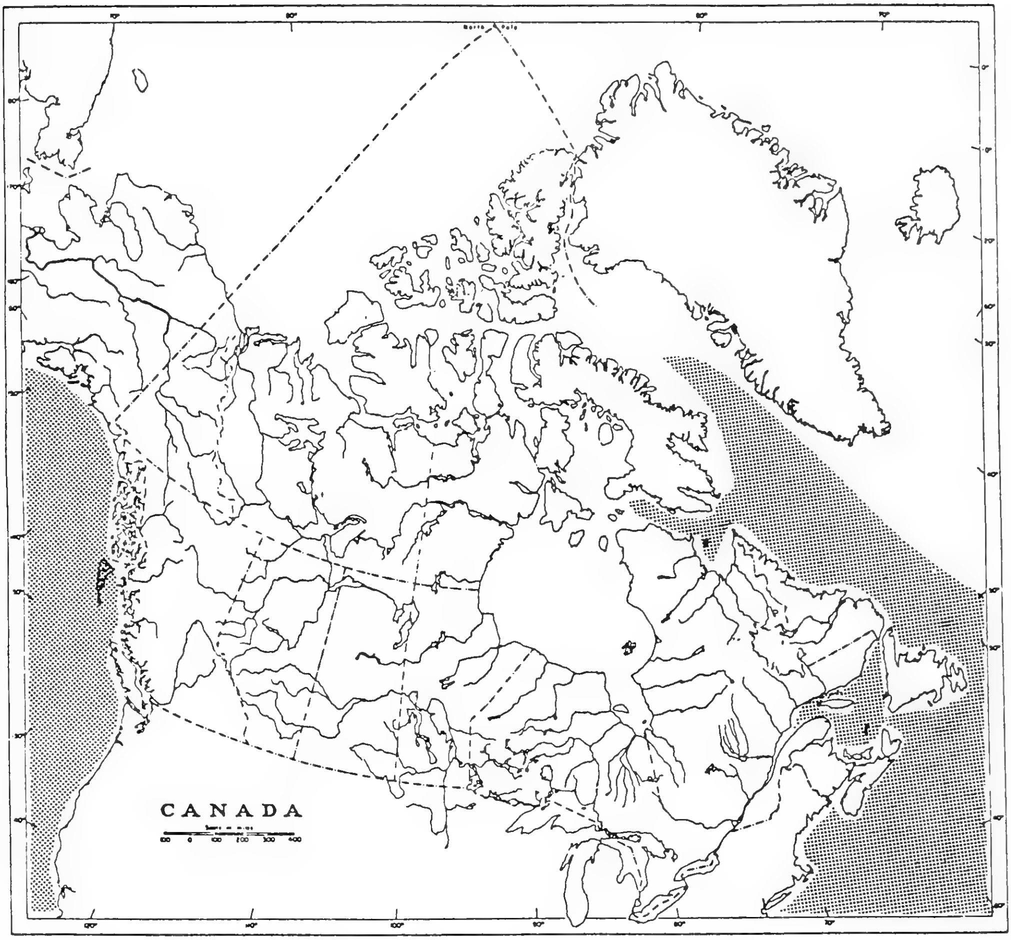

FIGURE 2. Distribution of the Blue Whale, *Balaenoptera musculus*, in Canadian waters.

General Biology

Most of the detailed accounts of Blue Whale biology result from studies carried out in the Antarctic (Mackintosh and Wheeler 1929; Nishiwaki and Hayashi 1950; Nishiwaki and Oye 1951; Ruud, Jonsgard, and Ottestad 1950).

The work has been well summarized in several more generalized accounts, particularly those of Ruud (1937, 1956). Perhaps the most important consideration of the Blue Whale's biology is its mode of feeding. Like most baleen whales it consumes plankton, but it is markedly stenophagous, its diet being restricted to euphausids (Beamish and Mitchell 1971; Gaskin 1976).

Limiting Factors

Commercial whaling has been the predominant cause of population decline, but the stocks are now protected from exploitation and should begin to increase. Whether or not they will reach pre-exploitation levels will depend on the extent to which they are affected by man's increasing activities in the marine environment, specifically in hydrocarbon developments. In this regard, whales do not migrate in large herds, but rather in twos or threes. Further, unlike Bowhead Whales (*Balaena mysticetus*) which skim their invertebrate food from the surface layers, Blue Whales generally feed below the surface.

Special Significance of the Species

The Blue Whale is the largest cetacean and also the largest mammal that has lived on earth. It was avidly sought after by the early pelagic whaling fleets, almost to the exclusion of other species, and as a consequence

became rapidly depleted in numbers (*see* Gulland 1972). These facts, more than any other, were probably most responsible for bringing the plight of the world's largest whales to the attention of the general public (*see* Small 1971).

Evaluation

The Atlantic Blue Whale stock was reduced by Canadian shore-based whaling and Norwegian pelagic whaling in the early part of the 20th century, but the decline in the Pacific stock was probably mostly brought about by whaling in Alaskan waters. Both stocks are probably building up gradually under complete protection. Overall, it can be said that the stocks are depleted but protected, and appear to be recovering with no apparent significant threats posed to their status. (At present, sightings in the Gulf of St. Lawrence are frequent in well-defined areas which were probably those of original abundance. Recovery may well be advanced). It would appear that neither the Pacific nor Atlantic populations were ever overly large and that both should be considered *rare*.

The Blue Whale meets the approved definition of *rare* occurring in small numbers in restricted areas in Canada, but not being threatened. It should be noted that the Blue Whale was probably always rare even before commercial whaling.

Acknowledgments

The author wishes to thank E. D. Mitchell and D. E. Sergeant of the Department of Fisheries and Oceans for their assistance and critical review of the manuscript and especially D. E. Sergeant for his helpful communications.

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Status of the Bowhead Whale, *Balaena mysticetus*, in Canada*

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The Bowhead Whale occurs in both the western and eastern Canadian Arctic in much reduced numbers after long periods of intense commercial whaling, principally in the 19th century. It is protected in Canada, but the western Arctic population is exploited during its migration to Canadian waters by the Alaskan Inuit under a quota set by the International Whaling Commission (IWC).

Le baleine boréale vit dans les eaux de l'Arctique canadien oriental et occidental. Son nombre restreint est la conséquence directe de la chasse commerciale intensive de ce mammifère, surtout au début du 19 siècle. Elle est protégée au Canada, mais les Inuits de l'Alaska exploitent la population de l'Arctique occidental au cours de sa migration vers les eaux canadiennes. Cette chasse est contingentée par la Commission baleinière internationale (CBI). [Traduit par R. R. Campbell]

Key Words: Bowhead Whale, *Balaena mysticetus,* baleen whale, whaling, Arctic whales, endangered.

The Bowhead Whale, or Greenland right whale, (*Balaena mysticetus*) is a large, slow-swimming baleen whale (Figure 1). The word "baleen" refers to the numerous long plates that are suspended in the mouth from arched upper jaws. These plates, made of a horny substance, enable the whale to collect and retain food. The Bowhead can grow to a length of nearly 18 metres and a weight of 70 tonnes, and is notable for its enormous store of blubber. Because of these characteristics, and the fact that the whales float when dead, the Bowhead and its near relatives were considered by whalers to be the right whales to hunt; hence the term "right" whale for members of this family, the Balaenidae.

Distribution

Western North American Arctic: migrates from the western Bering Sea and Gulf of Anadyr into the Chukchi Sea and eastern Beaufort Sea in April and May. Spends the summer off the west and south coasts of Banks Island and off the Canadian mainland coast in the vicinity of Cape Bathurst and Cape Parry. Returns to the Bering Sea in the fall (Fraker et al. 1978). Present distribution (Figure 2) restricted more to the north than during period of intensive American whaling from mid 19th to early 20th century (Townsend 1935).

Eastern North American Arctic: observations from eastern Arctic waters show great similarity in distribution (Figure 2) to former known whaling grounds. These include Cumberland Sound, east coast of Baffin Island, Pond Inlet, Lancaster Sound, Prince Regent Inlet, Roes Welcome Sound and southern Southampton Island (Lubbock 1955; Mansfield 1971; Ross 1974, 1979).

Protection

International: listed as a protected species by the International Whaling Commission. However, a take is permitted from the Bering Sea stock by aborigines, or on their behalf, with limits being: in 1978, up to 14 landed or 20 struck, whichever occurred first; and in 1980, up to 18 landed or 26 struck, whichever occurred first. The Bowhead is protected from international trade by listing on Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

National: Canadian whaling regulations prohibit the hunting and killing of any species of right whale (Balaenidae; including the Greenland right whale or Bowhead) except under a licence issued by the Minister of Fisheries and Oceans (Canada Department of Fisheries and Oceans 1979). No such permits have been issued.

Population Size and Trends

Western Arctic: the population that migrates along the north coast of Alaska was estimated at 2 264 from surveys conducted in 1978 (Braham et al. 1979). Numbers were much reduced by the American whale fishery in the 19th and early 20th centuries, from an estimated initial population of 11 700-18 000 (International Whaling Commission 1978).

Eastern Arctic: herds of up to 20 seen on several occasions, and up to 50 counted at one locality in a single season (Mansfield 1971; Greendale and

*Endangered status approved and assigned April 1980.

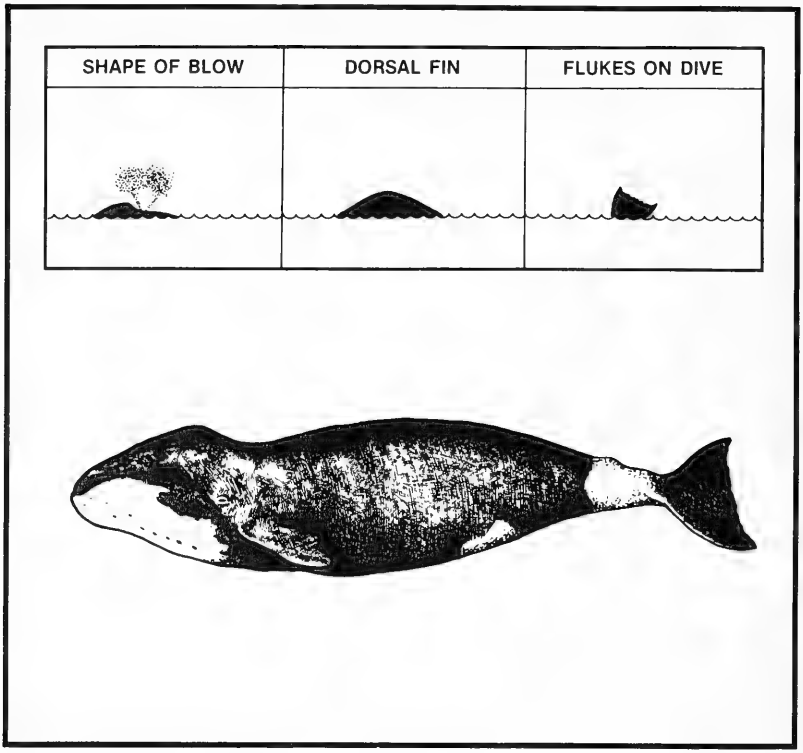

FIGURE 1. The Bowhead Whale, *Balaena mysticetus*.

Brousseau-Greendale 1976). Populations in Davis Strait and Hudson Bay were severely depleted in the 18th and 19th centuries. An estimated 28 394 were taken in Davis Strait from 1719 to 1911 and a further 572 in Hudson Bay from 1860 to 1915 (Ross 1979). The total number remaining is probably in the low hundreds, which must represent a small fraction of the initial stock size; according to Mitchell (1978), this is approximately 1 per cent of an initial stock size of about 6 000.

Habitat

Along the southern edge of the pack ice in winter, particularly in highly productive areas of mixed arctic and sub-arctic water: namely the Bering Sea and Davis Strait. Possible also in the permanent floe lead at the edge of the fast ice in western Hudson Bay. In summer, as far north as the edge of the multi-year polar pack, especially in productive areas such as Amundsen Gulf and Lancaster Sound.

Changes in the amount of drift ice, particularly in the Greenland current, were thought by Vibe (1967) to have destroyed the Bowhead's biotype in the northern Atlantic area, forcing the species away from its best feeding grounds and making it an easy prey for whalers (see also Durham 1972), but these ideas have not been generally accepted.

General Biology

The best general accounts of the habits of the Bowhead are still those of the whaling Captain William Scoresby (1820) in his history and description of the whale fishery, and of Charles Scammon (1874) in his account of the American whale fishery in the North Pacific. A most useful up-to-date summary is given by Marquette (1977).

The reproductive capability is unknown. Braham et al. (1979) recorded 18 young-of-the-year during the observations carried out at South Camp, Point Barrow, in the spring of 1978. These represented 1.3 per cent of the 1 389 counted, a value that the authors considered was most likely an underestimate because of the difficulty of viewing calves more than a few hundred yards off the ice edge. Marquette (1977) also thought it likely that cows with calves migrated later in the season after the observation camp had closed

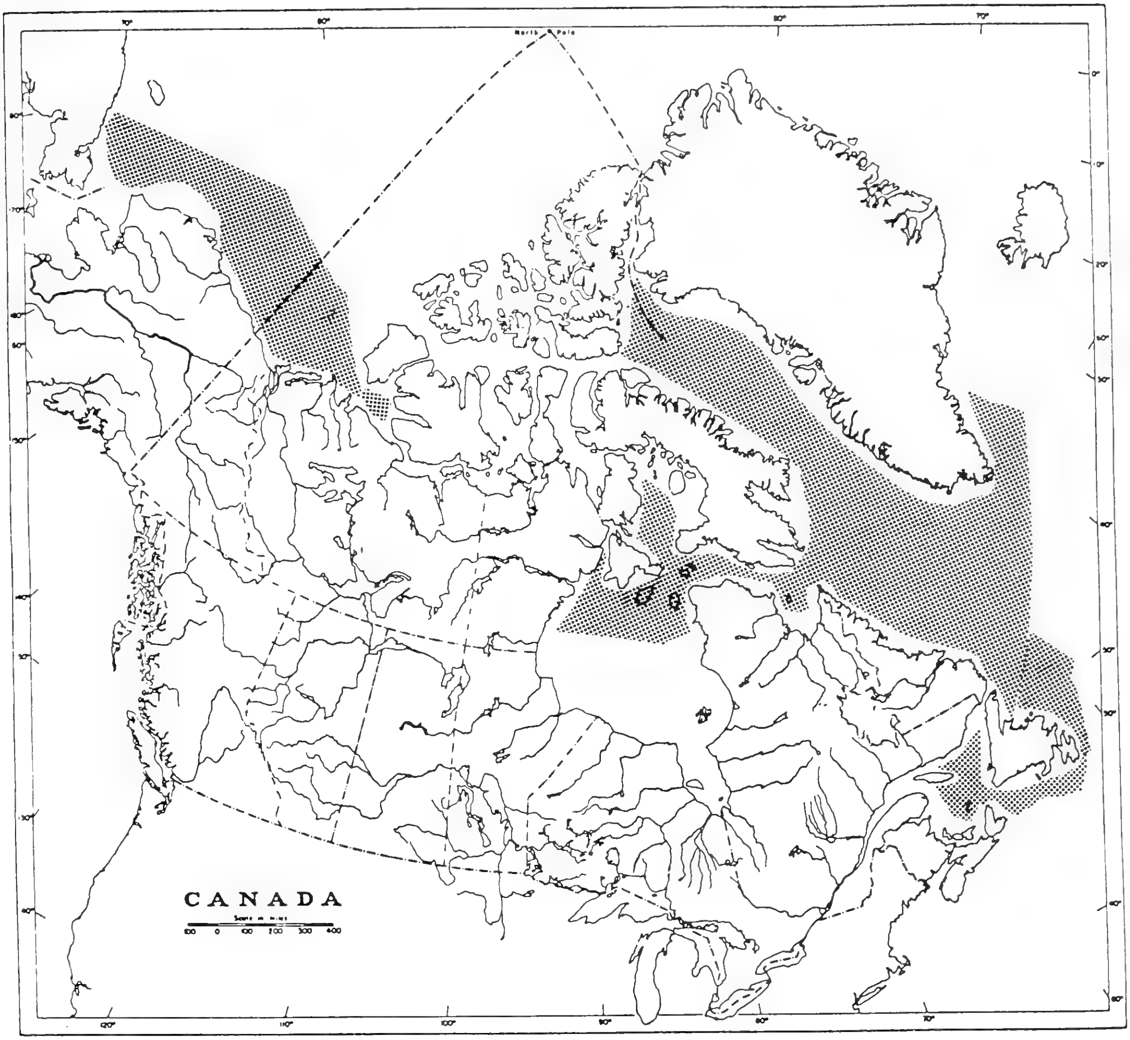

FIGURE 2. Canadian distribution of the Bowhead Whale, *Balaena mysticetus*.

down. However, the IWC Scientific Committee expressed concern over these interpretations, believing that the low number of calves observed might indicate a low recovery rate for this stock (International Whaling Commission 1979).

Food does not appear to be a limiting factor; stomachs examined have contained small planktonic crustaceans such as copepods, mysids, amphipods and euphausids, and on one occasion small bottom living organisms, sand and gravel (Marquette 1977; Johnson et al. 1966; Lowry et al. 1978). Bowheads seek out the more productive regions in summer which necessitates a migratory cycle linked to seasonal changes in the pack ice. The predictability of these annual movements leaves them especially vulnerable to human disturbance and capture, both on migration and during their summer feeding sojourn.

Limiting Factors

Predation by man has probably been the most overwhelming factor in the reduction of this species. Although few Bowheads have been taken in the eastern Arctic since commercial whaling stopped (1946), it is possible that continued attempts to kill them, though on a small scale, have effectively prevented any significant increase in this remnant population.

Special Significance of the Species

The recommendation by the IWC Scientific Committee that the Bowhead hunt in Alaska be stopped (International Whaling Commission 1978) has brought the species to the attention of the world's conservationists. Although the Commission itself has agreed to continued catches, the matter is subject to much dispute by the Alaska Eskimo Whaling Commission (AEWC) who wish to regulate the hunt themselves. The AEWC are now challenging the legal question of IWC jurisdiction in court (Adams 1979).

Evaluation

The main reason for the population decline has evidently been man's predation. The present IWC management regime for the western Arctic stock is a compromise between the recommendation of the Scientific Committee that no whales be taken until the stock has built up to the appropriate level, and the needs of the northern Alaskan Inuit whose culture has developed around the hunting of this species. Current stock levels would indicate that the population is endangered.

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Status of the Humpback Whale, *Megaptera novaeangliae*, in Canada*

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Humpback Whales frequent the waters off Canada's east and west coasts. Both stocks were heavily exploited commercially during the early twentieth century and this kept their numbers low until the International Whaling Commission assigned protected status to the North Atlantic stock in 1955 and to the North Pacific stock in 1965. Since this action was taken, the latter have not shown a marked increase, but in the Northwest Atlantic, Humpback Whale populations may have recovered. Recent estimates of the population size of the Northwest Atlantic Humpback Whale range from about 800 to 3 000 with the majority of estimates less than 1 500. The number of Northeast Pacific Humpbacks over-wintering around Hawaii has been estimated at 550-740 animals, with a mean of 650; this is to be compared to an initial population size of over 3 800 and possibly not less than 10 000 to 15 000. Both stocks are highly migratory. The North Pacific stock spends the summer in Alaskan waters and the winter around Hawaii. More is known of the North Atlantic stock which spends the winter in the West Indies where the calves are born. This population migrates to high latitude feeding grounds of the Northwest Atlantic, and Humpback Whales are numerous off Newfoundland/Labrador and west Greenland during the summer. However, the relationships of these two groups are uncertain. Although Humpback Whales may have recovered from earlier depleted population levels, they cannot be described as an abundant species. There remain small-scale subsistence fisheries for the species in west Greenland and Bequia, West Indies, and the effects of these removals on the conditions of the stock should be evaluated. In the late 1970's, Humpback Whales appear to have become increasingly numerous in inshore Newfoundland waters and there has been an increase in the frequency of entrapments of these whales in fixed inshore fishing gear. The apparent re-distribution of Humpback Whales may be correlated with depletion of offshore Capelin stocks. With recent rebuilding of these capelin stocks the whales have moved offshore. Humpbacks breed and calve on offshore Caribbean banks of limited extent, and they may be highly susceptible to human disturbance and pollution in these areas. Silver and Navidad banks, where 85 per cent of the population spend the winter, comprise only about 3 400 km^2.

Le rorqual à bosse fréquente les eaux au large des côtes orientales et occidentales du Canada. Une pêche commerciale intense au début du XX^e siècle a maintenue le nombre de ces deux populations très bas jusqu'à ce que la Commission internationale de la chasse à la baleine attribue le statut "protégé" au stock de l'Atlantique nord en 1955 et à celui du Pacifique nord en 1965. Depuis, ce dernier n'a pas beaucoup augmenté, mais les populations de rorquals à bosse de l'Atlantique du nord-ouest ont augmenté. Les récentes évaluations de la population de rorquals à bosse de l'Atlantique nord-ouest varient d'environ 800 à 3 000, la plupart des estimation étant de moins de 1 500. Le nombre de rorquals à bosse du Pacifique nord-est qui hivernent autour d'Hawaii a été évalué entre 550 et 740, avec une moyenne de 650; par comparaison, la population initiale comptait plus de 3 800 animaux et possiblement pas moins de 10 000 à 15 000. Les populations des deux régions ont des habitudes de migration très marquées. Celle du Pacifique nord passe l'été dans les eaux de l'Alaska et l'hiver autour d'Hawaii. On connaît mieux le stock de l'Atlantique nord qui passe l'hiver dans les Antilles où naissent les baleineaux. Cette population migre très haut dans le Nord, dans le nord-ouest de l'Atlantique où se trouvent leurs aires d'alimentation, et les rorquals à bosse sont très nombreux au large de Terre-Neuve et du Labrador et de la côte ouest du Groenland en été. Cependant les rapports entre ces deux groupes sont inconnus. Bien que leur nombre ait augmenté au cours des dernières années, les rorquals à bosse ne peuvent être considérés comme une espèce abondante. Il existe encore de petites pêcheries de subsistance qui exploitent l'espèce sur la côte ouest du Groenland et à Béquia dans les Antilles, et il faudrait évaluer les effets de ces prises sur la condition du stock en général. Vers la fin des années 1970, les rorquals à bosse semblaient de plus en plus nombreux dans les eaux côtières de Terre-Neuve et beaucoup se faisaient prendre dans les engins de pêche fixe. L'apparente nouvelle répartition des rorquals à bosse est peut-être la cause de la baisse des stocks de capelans au large. En effet, ces stocks semblent se reconstituer et les rorquals se sont éloignés au large. Les rorquals à bosse s'accouplent et mettent bas sur les bancs au large des Caraïbes et ils sont probablement très vulnérables aux perturbations et à la pollution par l'homme de ces zones très limitées. Les bancs Silver et Navidad où 85% de la population passent l'hiver ne couvrent qu'environ 3 400 km^2. [Traduit par R. R. Campbell]

Key Words: baleen whales, Humpback Whales, *Megaptera novaeangliae*, Atlantic whales, Pacific whales, whaling.

The Humpback Whale (*Megaptera novaeangliae*) is a stocky baleen whale of the family Balaenidae (Figure 1) which rarely exceeds 15 metres in length and 32 tonnes in weight. The name is derived from the 'step' anterior to the dorsal fin which may be quite pronounced in some individuals, producing a humplike aspect as the whale dives. Humpbacks are generally black above and white below, but there is much

*Threatened status approved and assigned 6 April, 1982.

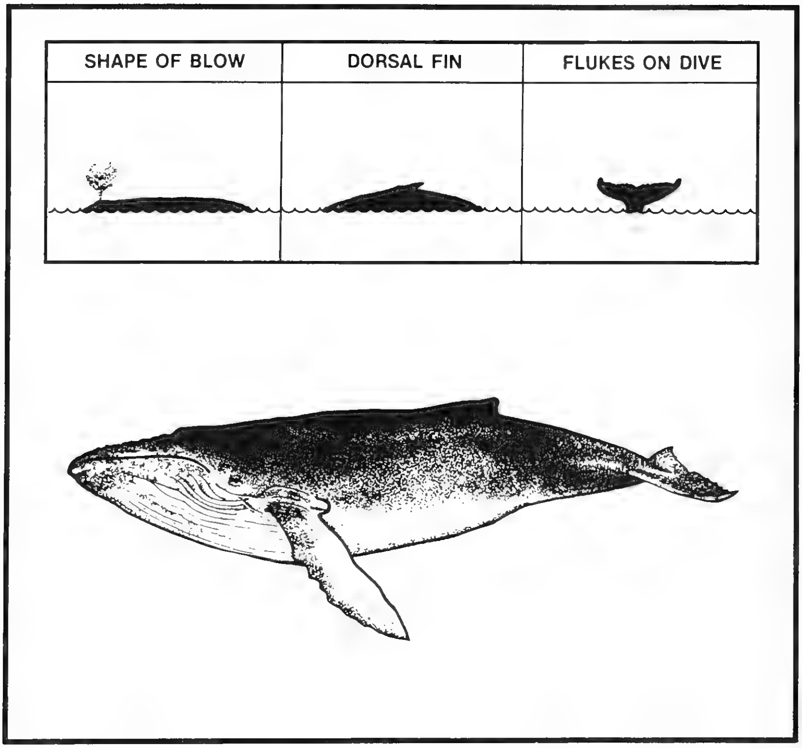

FIGURE 1. The Humpback Whale, *Megaptera novaeangliae*.

variation in the whiteness of the undersides. The flippers, the longest of any of the whales, may be one-third the length of the animal giving them greater maneuverability, as swimming is accomplished by up and down movements of the tail. The flukes are gracefully curved and notched on the medium line and the trailing edge is always scalloped. Flippers and flukes are usually white ventrally and mixed black and white dorsally; individuals can be identified by their unique patterns. Another distinguishing feature of the Humpback is the series of bumps on the upper jaw and on the fleshy proturberance at the apex of the lower jaw. These bumps contain bristles which may serve a tactile purpose in sensing movement of prey and water currents.

Distribution

Humpback Whales were formerly abundant in the waters off British Columbia including the Strait of Georgia where they are now seldom encountered (Pike and MacAskie 1969). The whales migrate between Alaska, where they spend the Summer, through Canadian and Mexican waters (Figure 2) to Hawaii where they over-winter.

Northwest Atlantic Humpback Whales are distributed (Figure 2) from the West Indies to southern Labrador, Davis Strait, and southwestern Greenland. They occur off Bermuda during their spring migraton (Winn, Edel and Taruski 1975). The Humpback is a highly migratory whale that frequents both inshore waters and open ocean waters (Mitchell 1974).

In eastern Canada during summer, Humpback Whales are common in inshore Newfoundland waters (mainly off the south and east coasts), the waters off southeastern Labrador, the Grand Banks (mainly along its edges), and the southern gulf and estuary of the St. Lawrence (Sergeant 1966). There is no evidence to suggest a change in the distribution of Northwest Atlantic Humpbacks in response to exploitation during this century.

Protection

Humpback Whales of the North Pacific have been officially protected from commercial whaling activities since 1965, by the International Whaling Commisson (IWC), while those of the North Atlantic have been similarly protected since 1955. Aboriginal whaling does occur both off western Greenland and

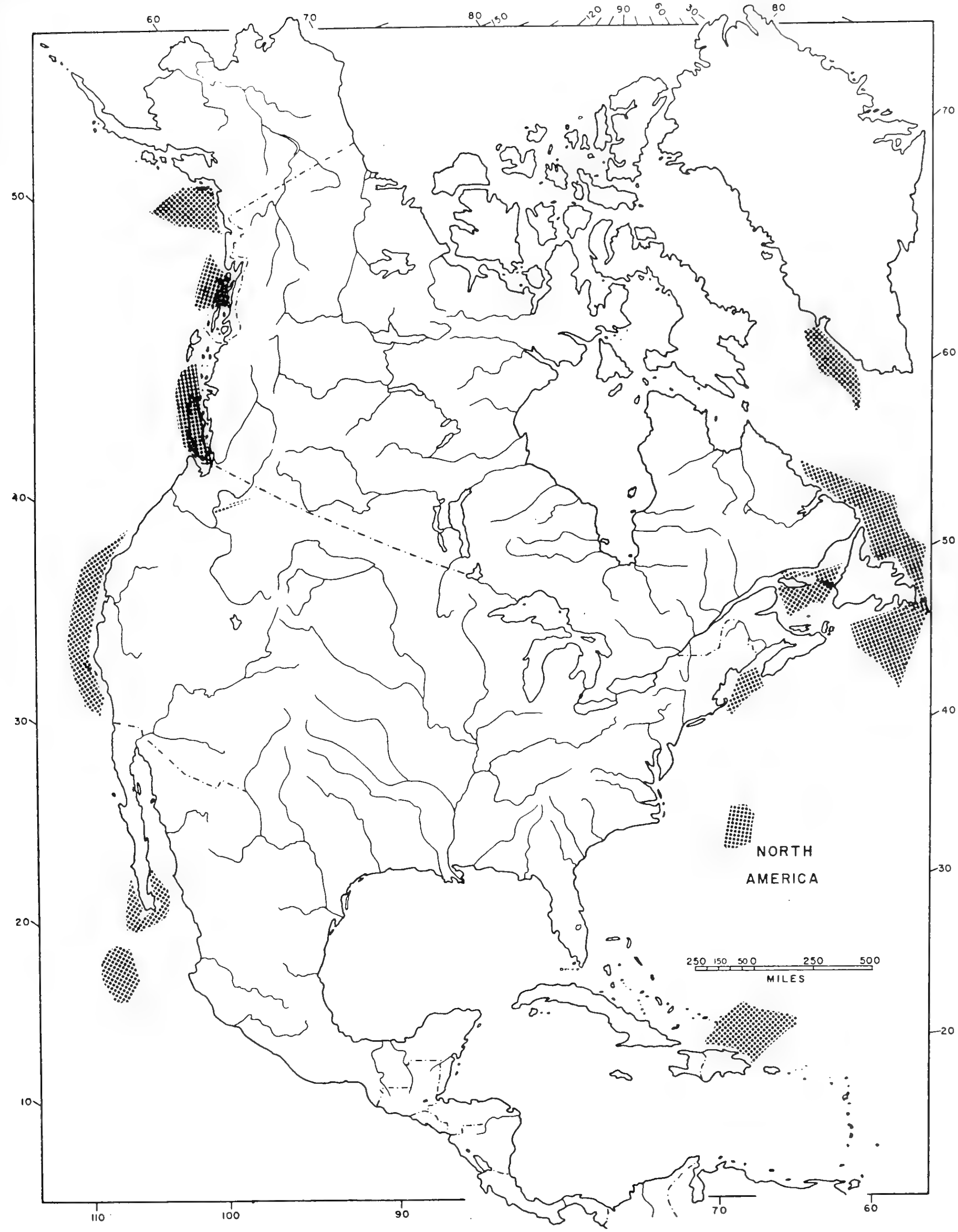

FIGURE 2. Areas in North America where Humpback Whales, *Megaptera novaeangliae*, commonly occur

Bequia, West Indies. Canadian Whaling Regulations prohibit whaling in Canadian waters and the species is protected from international trade by listing on Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

Population Size and Trends

North Pacific

No firm estimates of the population size of Humpbacks in British Columbia waters are available. The number of whales over-wintering around Hawaii has been estimated at 550-740 with a mean of 650. It has been suggested that the initial population size must have exceeded 3 500 animals and might possibly have reached 10 000 to 15 000, but supporting evidence is lacking. More data on the present Hawaiian population is expected in the near future. Prior to 1913, whaling stations along the west coast of Vancouver Island annually caught between 500 and 1 000 whales, almost exclusively Humpbacks. The catch of this species declined in relation to that of other species until 1948, when an operation at Coal Harbour took 115 Humpback Whales. By 1965, Humpbacks comprised only about 2 per cent of the total catch of large whales. Catch records suggest (see Appendix I of Pike and MacAskie (1969)) that Humpbacks may have numbered in the low thousands off the British Columbia coast during the early years of this century.

North Atlantic

Humpback Whales were heavily exploited in Newfoundland during the early years of the twentieth century and Sergeant (1966) suggests, using cumulative catch records, that their population size was about 1 500 prior to about 1898. Humpback Whale catches remained low until 1955, when they were finally given full protection in the North Atlantic by the IWC. Humpback Whales may now have recovered their numbers to the pre-1900 level (about 1 500; *see* Sergeant 1966), as indicated by recent estimates of the population size of the Humpback Whale in the Northwest Atlantic. Probably only a few hundred Humpbacks remained by 1915, a year in which only five were caught in Newfoundland waters (Sergeant 1966; Winn, Edel and Taruski 1975).

Mitchell (1973), utilizing strip census shipboard surveys during 1966, 1967, and 1969, concluded that the summer population size of western North Atlantic Humpbacks was about 1 260. He assumed a total transect width of eight nautical miles, but thought that the resulting population estimate was probably too high.

Winn et al. (1975) estimated that the population size of Humpbacks during 1972-73 on the Caribbean calving grounds averaged 1 018 animals, with a range of 785 to 1 157. About 85 per cent of this wintering population occupied the Silver and Navidad Banks, where densities of Humpbacks were highest. Winn et al. (1975) suggest that their estimate might be slightly conservative for a variety of reasons. For example, the migratory Humpbacks that occur on the Bermuda Banks in April may either represent a separate stock of about 80 whales or be migrants from the West Indies (Winn et al. 1975).

Balcomb and Nichols (1978) used similar methods to estimate a population of 905 Humpback Whales on Silver and Navidad Banks in early March 1977. This population was further assessed the following winter by Whitehead (1979. Populations of Humpback Whales on Silver, Navidad, and Mouchoir Banks during the winter 1977-78. Unpublished manuscript), who estimated that a peak population of 3 000 Humpback Whales occurred on Silver, Navidad, and Mouchoir Banks during the 1977-78 winter. Peak populations were as follows (95 per cent confidence limits in parentheses):

Date	*Bank*	*No. of Whales*
7-15 March	Silver	2 642 (2 115-3 129)
3-12 February	Navidad	767 (589-945)
10-11 March	Mouchoir	167 (49-285)

This survey ran from 12 December 1977 to 20 April 1978 and is the most comprehensive of all censuses of Humpbacks on these banks to date. Whitehead (1979) concluded that as no major winter concentrations are reported elsewhere, the majority of the Northwest Atlantic stock of Humpbacks winter on these three banks.

Individuals that winter entirely in high latitudes must be added to population estimates of Humpbacks wintering in the West Indies. Sergeant (1966) and Williamson (1961) noted several sightings of Humpbacks from December to April in eastern Canadian waters. However, Winn et al. (1975) remarked that none of these northern sightings were made in January and February, and this fact, coupled with the observation that many individuals arrive in the West Indies in January and start to leave by mid-March, suggests that many of the northern winter records do not represent true over-winterings. Thus, they should not be added to West Indies population estimates. However, good evidence for over-wintering of a very small proportion of the population in northern areas exists (*see* General Biology), but this has not been evaluated.

The recent estimates of Northwest Atlantic Humpback Whale population size suggest that numbers have increased markedly since they were depleted in the early years of this century; these recent estimates

are also close to Sergeant's (1966) estimate of the population size of Humpbacks prior to the onset of heavy exploitation in 1898, suggesting that they may have recovered fully to this level. No population estimate of Humpback Whales is available for the years around 1955, so that the effects of protection given at that time are unknown (Winn et al. 1975). However, in the immediate post-war years, up to 1951, Humpback Whale catches in Newfoundland and Labrador were very low (5 to 29 per annum) while Fin Whale (*Balaenoptera physalus*) catches were high, suggesting that Humpbacks were probably depleted by 1955 (Sergeant 1966). Hence, the protection extended to Humpback Whales in that year allowed the subsequent recovery of the population.

Whitehead (1979 unpublished study) pointed out that most vessel surveys of Humpbacks on the Caribbean calving grounds and elsewhere have used transect widths that were not scientifically or empirically derived and that were in all probability overestimates; therefore, total population sizes estimated in these studies are probably underestimates and are not strictly comparable with each other.

The pre-exploitation population size of North Atlantic Humpbacks is impossible to assess. They were probably heavily hunted by Basque Whalers in eastern Canadian waters, along with Right Whales (*Eubalaena glacialis*), from the early or mid-sixteenth century.

Habitat

The habitat where North Atlantic Humpbacks breed and calve consists of shallow offshore banks of rather limited extent in the West Indies. According to Winn et al. (1975), these banks are 10 to 100 fathoms deep and comprise about 65 000 km^2. All of the Humpback Whales in these waters are found on the outer windward (Atlantic) coasts of the Caribbean Islands. Those outer windward coasts with narrow shelves, generally less than two miles wide, do not harbor whales. Most (85 per cent) of these wintering Humpback Whales are found on the Silver and Navidad Banks, north of the Dominican Republic (Winn et al. 1975). These two banks have a combined area of about 3 400 km^2, and probably provide ideal conditions for nursing females and their newborn calves, but these nursery areas are not formally protected from any disturbance except commercial whaling.

The distribution of Humpback Whales in northern waters is largely influenced by the distribution of their prey, which consists primarily of the small schooling bait-fish, Capelin (*Mallotus villosus*), and various species of euphausids (krill). Humpbacks have traditionally been numerous on the Grand Banks during June and July, especially on the Southeast Shoal, where they feed on aggregations of spawning Capelin (Williamson 1961; Sergeant 1966). They also tend to frequent the edges of the Grand Banks in summer (Sergeant 1966); these slope areas would presumably be areas of high productivity and food production for Humpbacks. In recent years, Humpbacks have been numerous in inshore Newfoundland waters where they feed on aggregations of beach-spawning Capelin. The timing of their residence in inshore waters seems to coincide with the Capelin spawning season (Perkins and Beamish 1979).

Less information is available on the North Pacific stock. Whales inhabit the rich northern feeding grounds off Alaska and have been sighted in the northern Bering and Chukchi Sea in the summer months over the period 1969-78. These are the first known reported sightings of Humpback Whales so far north for several decades. These whales over-winter and calve in the shallow waters around Hawaii.

General Biology

Reproductive Capability

Humpback Whale females produce one calf every two years; gestation lasts about one year and lactation, about 10 months. Seasonal changes in length of foetuses from Humpbacks captured under special scientific permit by eastern Canadian land stations during 1969-71, suggest that the breeding season is late winter to early spring (Mitchell 1973). The birth rate of the Northwest Atlantic population of Humpbacks, as indicated by the proportion of calves in the population on the calving grounds in early March 1977, is 10.1 per cent (Balcomb and Nichols 1978).

Migration

The migratory cycle of Northwest Atlantic Humpback Whales is generally well-known. This population mates and calves on warm shallow banks near the West Indies from January to April (Winn et al. 1975) and feeds during most of the remainder of the year in cold northern waters, mainly off the east coast of Newfoundland, southeast Labrador, and west Greenland. The exact relationships between Humpbacks off Newfoundland-Labrador and West Greenland are unknown (Mitchell 1974), but a direct connection between the West Indies and Newfoundland, using the method of identification of individuals by the unique colouration pattern on the ventral surface of the flukes, has recently been documented (Balcomb and Nichols 1978). This technique may well have application in elucidating migration patterns and stock relationships of both the Northwest Atlantic and the North Pacific Humpback Whales.

A very small proportion of the North Atlantic pop-

ulation may over-winter in northern waters. This is evidenced by the observation of five Humpbacks trapped by ice in Hall's Bay, Newfoundland during February to April 1978 (Fruchtman 1978) and the observation by Williamson (1960) of a female and calf and one other adult on the southern edge of the Grand Banks in early March 1961. In addition, Sergeant (1966) documents several sightings of Humpbacks in eastern Canadian waters during November, March, and April of various years. It is clear that a large proportion of the population migrates south to low latitudes for breeding, but in recent years fair numbers of whales have been observed in inshore Newfoundland waters during mid-winter (e.g. good numbers of Humpbacks were observed in Green Bay, Newfoundland during November 1978 to January 1979).

With respect to the North Pacific Humpbacks, less work has been done to date. However, a connection between the summer Alaskan and the winter Hawaiian stocks has now been definitely established by recognition of four individual whales from their fluke pattern and scoring. This confirms the north-south migratory pattern of the North Pacific stock which parallels that of the North Atlantic Humpbacks.

Behaviour/Adaptability

Although Humpback Whales are considered to be generalists in their feeding habits, they take mainly Capelin in the Northwest Atlantic with euphausids as a second choice, the latter being taken through their specialized mouth parts, baleen (Mitchell 1975; Sergeant 1966). While in inshore waters around Newfoundland, they may be taking squid and mackerel, which are abundant there during summer, in addition to Capelin. The latter predominated in the stomach contents of the 41 Humpbacks taken under special permit in 1969-71, although krill was found in four stomachs and sand lance and mackerel were each noted on one occasion (Mitchell 1973).

Limiting Factors

The Humpback Whale of the western North Atlantic has demonstrated considerable recovery since formal protection of this stock was established by the IWC in 1955. Its present size appears to be similar to the pre-1900 level, and this particular population of Humpbacks is no longer endangered. The same cannot be said of the North Pacific stock which has not demonstrated such a spectacular recovery since protected status was assigned to it. The North Atlantic stock does not seem to have suffered from potential competition with sympatric Fin Whales and Minke Whales (*Balaenoptera acutorostrata*) for Capelin and/or euphausids (Mitchell 1975), and, in fact, the Humpbacks generalist feeding habits may have promoted their recovery since the cessation of commercial whaling. All three species are often observed feeding in the same general area, apparently on the same food organism (Capelin or krill).

The main predator of the Humpback Whale is the Killer Whale (*Orcinus orca*). As the latter is apparently quite scarce along the coasts of Newfoundland, predation on Humpbacks is not considered to be a factor limiting their survival and recovery. There is no evidence of the effects of such predation on North Pacific Humpbacks at this time.

The potential commercial production of oil from the Grand Banks of Newfoundland and off Labrador constitutes a new threat to seasonal North Atlantic whale populations. Several test-wells have been drilled to date and one has actually struck oil. Exploratory activity is increasing and there is general optimism that large commercially-viable oil fields exist. The possible effects of an uncontrolled blow-out on summering whales dependent on the rich feeding banks off Newfoundland and Labrador are undefinable at this time. However, since Humpbacks do feed near the surface utilizing their baleen to capture Capelin and euphausids, the probability of oil clogging of their baleen would seem to be a potential threat.

In spite of the possibility that western North Atlantic Humpbacks have recovered to their pre-1900 level, another threat to the population has appeared. In the 1970's spawning Capelin stocks on the Grand Banks were severely depleted by foreign fishing activity, especially in the vicinity of the Southeast shoal. Considerable numbers of Humpbacks have traditionally fed upon Grand Banks' Capelin during the summer (Sergeant 1966), especially in late June and July when these offshore stocks of Capelin spawn. In recent years (e.g. 1978) Humpbacks have been scarce on the Southeast Shoal of the Grand Banks, and this is correlated with depletion of spawning Capelin in the area (Carscadden and Miller 1979). Protection was given to Grand Bank's Capelin stocks in 1979. In late June, 1979, approximately 40 Humpback Whales were observed on the Southeast shoal by Dr. J. E. Carscadden from the research vessel *Gadus Atlantica* in an area where substantial amounts of Capelin were being caught.

Coincident with the decrease in the number of Humpback Whales feeding on the Southeast shoal was an apparent increase in the number of Humpback Whales (and possibly also Fin Whales) in inshore waters during the summer. Here they come into conflict with inshore fishermen who were increasingly catching whales accidentally (mostly Humpbacks) in their fixed fishing gear (mainly cod traps and gill nets). Perkins and Beamish (1979) documented several net entanglements of baleen whales in Newfoundland

inshore waters up to and including the 1977 fishing season, and they found that these entanglements are most frequent during the Capelin spawing season. It was speculated that whales were moving inshore to feed on the more abundant stocks of inshore Capelin (or other possible prey items, such as herring, mackerel and squid) since the Grand Bank's Capelin stock has been depleted; hence the conflict between whales and the inshore fishery. The distribution of past commercial Humpback Whale catches (Sergeant 1966) and special scientific catches during 1969-71 (Mitchell 1973) seems to suggest that the summer distribution of Humpback Whales did change in the late 1970's; whales which perviously utilized offshore feeding banks now visited inshore areas for feeding. However, in the past two years the situation has changed; offshore Capelin stocks have increased and apparently the whales have responded for there are reduced numbers of entrapments and increased offshore sightings.

Humpback Whales mate and calve on offshore banks (10 to 100 fathoms deep) of rather limited extent in the West Indies. The most important of these are Silver, Navidad, and Mouchoir Banks, north of the Dominican Republic. These banks must provide conditions appropriate for the survival of newborn Humpbacks. Because of the limited extent of these banks lactating females and their newborn calves might be highly susceptible to human disturbances, such as heavy ship traffic and oil spills. About 85 per cent of the western North Atlantic calving population occurs on Silver and Navidad banks which together comprise only 3 400 km^2.

Although Humpback Whales of the western North Atlantic are officially protected from commercial whaling, native residents of Greenland and Bequia, West Indies, continue to take a small number of Humpbacks annually. The annual catch at Bequia is 0 to 6 whales (Winn et al. 1975) while that at Greenland is up to 100 animals (Mitchell 1973). However, the effects of these catches on the stocks of Northwest Atlantic Humpback Whales have not been assessed.

Special Significance of the Species

The Humpback is one of the great whales well known to the public due to extensive media coverage. This began locally in Newfoundland where attention was drawn to whale entanglement in inshore fishery gear.

In the eyes of the public, the fishermen's economic losses were subordinate to the plight of the whales. Interest will continue and the species used, perhaps, as an indicator of the Government's interest in and concern for those Canadian marine mammals which are now threatened or endangered.

Evaluation

North Atlantic

This stock has demonstrated a significant recovery from the depleted population levels which prevailed early in this century, primarily as a result of the protection extended to this species in 1955 by the IWC. The Humpback is a very adaptable species and appears to be quite flexible or general in its feeding habits. As a result, when the species was scarce and protection was finally extended in 1955, Humpback Whales were able to compete successfully with the more numerous Fin and Minke whales, allowing the stock to build back up to near its original size. Although there is now no need to be concerned about the survival or recovery of the population, the recent increase in net entanglements of whales in the Newfoundland inshore fishery and the re-distribution of whales into inshore waters, possibly due to depletion of bait-fish in offshore areas, must be viewed with some concern in terms of possible future declines in the population size of their principal prey. The effects of continued hunting of Humpbacks by natives of west Greenland and Bequia, West Indies, should also be evaluated. Humpback Whales may be a valuable tourist resource since they are quite tame and concentrate in certain inshore areas during summer.

In view of the above, this stock should be placed in the *threatened* category with a later move to the *rare* category if the stock continues to build and the fishing gear mortality rate is reduced to an acceptably low level.

North Pacific

The picture is less clear for this stock. As numbers are low and our knowledge presently severely limited, it is recommended that this stock be placed in the *threatened* category pending more research to assess its current status and its susceptibility to industrial activities along its migratory route and northern feeding grounds.

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Status of the Right Whale, *Eubalaena glacialis*, in Canada*

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Hay, K. A. 1985. Status of the Right Whale, *Eubalaena glacialis*, in Canada. Canadian Field-Naturalist 99(3): 433–437.

Populations of Right Whales of the eastern North Pacific and Western North Atlantic have been reduced to mere remnants of their original sizes due to commercial whaling, and, in spite of protection for half a century or more, they may still be in danger of extinction or may not be able to recover their numbers to a significant biological level. Factors that may be preventing their recovery are identified and discussed. Research on these factors and subsequent development of management strategies to enhance the recovery of the species must be initiated at once. Increased sightings of Right Whales in coastal waters in recent years may not reflect actual population increase, but rather increased observer effort.

Les populations de baleines noires de la partie nord-est du Pacifique et de la partie nord-ouest de l'Atlantique ont été décimées à la suite de la chasse commerciale, et bien qu'elles soient protégées depuis plus de 50 ans, elles sont encore menacées d'extinction et leur productivité biologique pourrait rester faible. Le présent rapport identifie et analyse les facteurs qui limitent leur régénération. Il est important d'entreprendre immédiatement des recherches sur ces facteurs et d'élaborer des stratégies de gestion pour favoriser la régénération de l'espèce. Les observations plus nombreuses de baleines noires dans les eaux côtières au cours des dernières années ne reflètent pas nécessairement un accroissement réel de la population, mais plutôt un effort plus soutenu des observateurs. [Traduit par R. R. Campbell]

Key Words: baleen whales, Right Whale, *Eubalaena glacialis*, endangered, whaling.

The Right Whale or black right whale (*Eubalaena glacialis*) (Figure 1) is a large baleen whale belonging to the family of Balaenidae. Several members of this family, including the Bowhead (*Balaena mysticetus*), another endangered species, are commonly referred to as "right" whales, because their large size and huge quantity of blubber made them very desirable to whalers. The Right Whale has large baleen plates, used for filtering food, attached to the inside of the high, arched upper jaws. There are no fins on the back. Other characteristics of this whale are the hard bumps on the snout and lower jaws, and the twin blowholes that spout water in a V-shape. Right Whales grow to a length of 15 to 18 metres and weigh about 54 tonnes.

Distribution

Right Whales of the eastern North Pacific are distributed from Oregon to the waters off Alaska and the Bering Sea (Figure 2). Although now much reduced in numbers from previous levels, there is some indication that Right Whales occupied waters as far south as California during former periods of abundance.

Right Whales of the western North Atlantic are distributed from the Gulf of Mexico to the waters off Newfoundland (Figure 2). Reeves, Mead, and Katona (1978) summarize a number of capture, stranded, and sight records of Right Whales during the whaling period (pre-1937) and the period of protection (post-1937). These give a fairly accurate picture of the past and present distribution of this species in the western North Atlantic.

In eastern Canada, Right Whales formerly occurred in some abundance in the Gulf of St. Lawrence and along the southern coast of Newfoundland, but they are now rarely seen in these areas owing to the early Basque Whale Fishery. Right Whales are still occasionally seen in Newfoundland and Nova Scotia inshore waters during the summer.

J. A. Allen (*cited in* Reeves, Mead, and Katona 1978) felt that, prior to its intensive exploitation, the Right Whale ranged throughout the entire temperate zone:

> ". . . from the coast of Florida and the Bermudas on the western side to the entrance to Davis Strait, the southern and southwestern coast of Greenland, and the waters about Iceland; and on the eastern side from the coast of Spain and (casually at least) the Mediterranean Sea northward to the seas between Norway and Spitsbergen".

He added that it probably occupied "the northern part of this area in summer, and the southern part in winter".

Protection

The Right Whale has been protected in North Atlantic waters since 1937, and is today protected from commercial whaling activity in all oceans, being listed as a Protected Stock by the International Whal-

*Endangered status approved and assigned by COSEWIC April 1980.

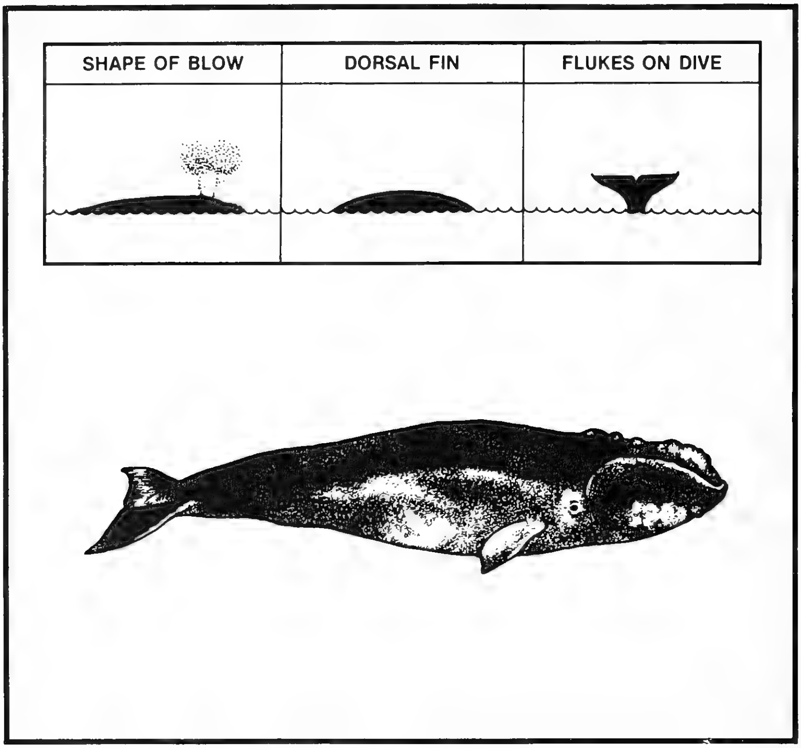

FIGURE 1. The Right Whale, *Eubalaena glacialis*.

ing Commission (IWC). In addition, the species is listed on Appendix I (endangered species) of the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) to which Canada is an adherent. Canadian whaling regulations also prohibit the taking of whales in Canadian waters.

Population Size and Trend

Right Whales of the eastern North Pacific Ocean are scarce; neither numbers nor trend have recently been assessed. They appear, however, to have been greatly diminished in numbers due to whaling in the nineteenth century. Pike and MacAskie (1969) list four captures of Right Whales taken by British Columbia whaling stations (prior to their closure in 1971) and only three offshore records of the species reported since 1958.

Although no special censuses of the population have been undertaken, Right Whales are rare in the western North Atlantic, much reduced from previous levels through intensive hunting over about 400 years. They were apparently numerous off Florida and around Bermuda prior to the onset of their exploitation. They were sufficiently abundant off South Carolina and Georgia during the late 19th century to enable the prosecution of a limited coastal fishery. However, these fisheries took only a few animals annually, indicating that the species was quite scarce even then. Basque whalers took large numbers of Right Whales in the Gulf of St. Lawrence from the mid 16th century; Right Whales are now apparently extremely uncommon in the Gulf. The species is generally rare in eastern Canadian waters. Mitchell (1975) concluded that the Northwest Atlantic stock of Right Whales may number "only tens to a few hundred animals", in spite of almost complete cessation of whaling for this species along the east coast of North America more than 50 years ago. However, 70 Right Whales were seen on one spring day in 1970 off Cape Cod (observation of W. Schevill, *in* Reeves, Mead and Katona 1978).

Habitat

Eastern North Pacific Right Whales were formerly caught in the Gulf of Alaska and southward to the north end of Vancouver Island mostly during May,

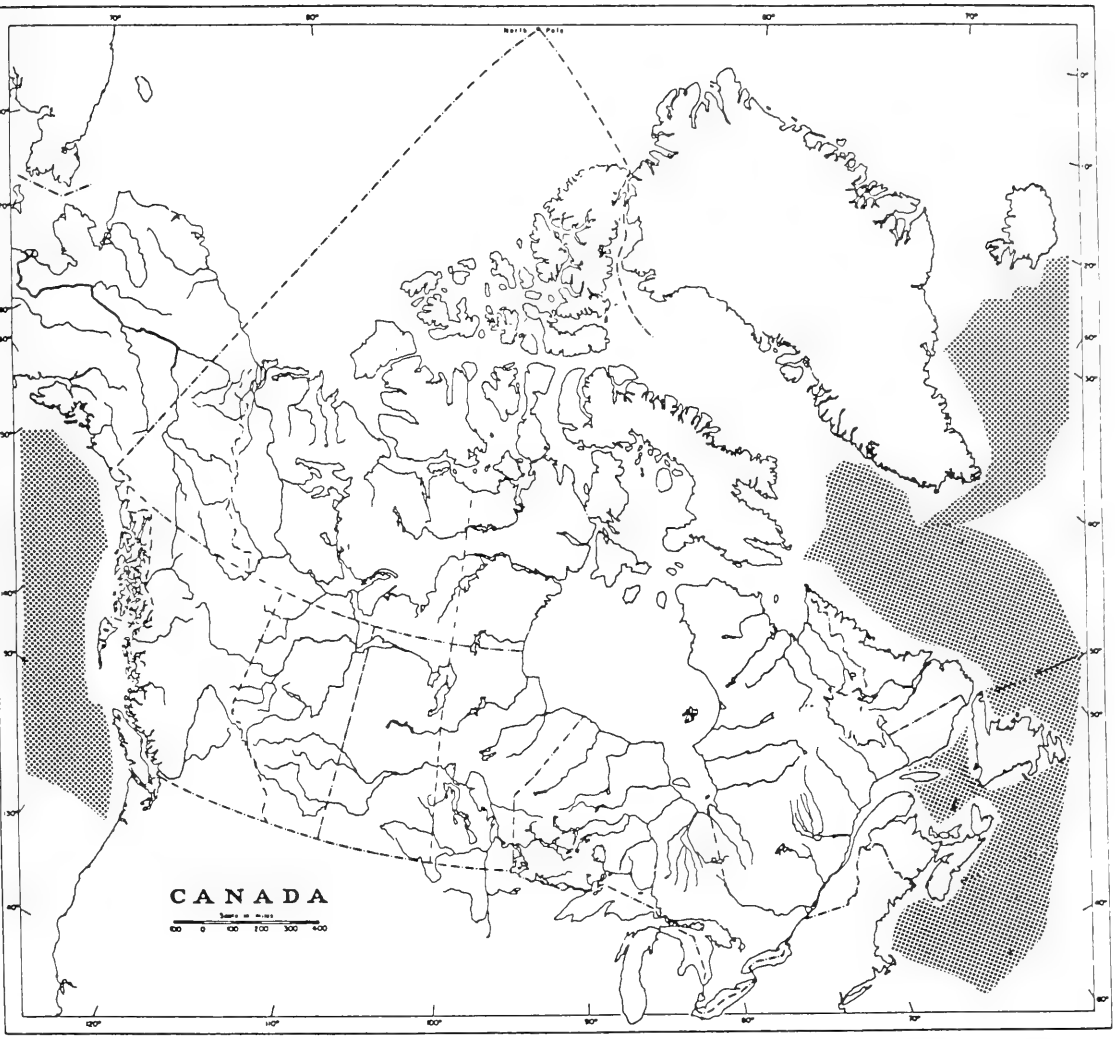

FIGURE 2. Possible Canadian distribution of the Right Whale, *Eubalaena glacialis*.

June and July, and in the Bering Sea mostly during August and September. Individuals therefore, show a generally northward migration in summer. Waters off British Columbia, Washington, Oregon, and California were probably wintering grounds for this species during former periods of abundance before American whalers had decimated the population during the second half of the 19th century.

Western North Atlantic Right Whales also appear to exhibit regular seasonal north-south migrations, as indicated by the distribution of captures, sightings, and strandings along the eastern coast of North America (Reeves, Mead, and Katona 1978). A fishery centered at Cape Lookout, North Carolina, during the second half of the 19th century took northbound Right Whales during February through April. Most of the records of Right Whales from the southeastern coast of the United States (North Carolina southward) and Gulf of Mexico were obtained in late winter and early spring (late December to early April); newborn Right Whales have been reported in these waters. Most of these southern records probably represent both overwintering whales and the start of a near-shore northward spring migration.

Right Whales on northward migration reach Delaware Bay and the New York Bight during April and

May. However, some Right Whales winter(ed) in Delaware Bay and along the coasts of New Jersey and southern Long Island. It seems likely that migrants from the south augment(ed) the wintering population in these regions, causing a peak of abundance between February and May. Summer and early fall records in the New York Bight may represent juvenile whales that do not undertake marked migrations.

Whaling records suggest that Right Whales reach New England (from the north) during late October, building to a winter peak in December. "The decrease after December, no doubt indicates an actual migratory movement to the south" (G. M. Allen 1916, *cited by* Reeves, Mead and Katona 1978). A few animals may, however, over-winter in the New England area. Their peak occurrence in New England (as a result of a movement from the south) was between mid-February and the end of May, and they are absent there during mid-June to early October. In recent years, numerous sightings of Right Whales off Cape Cod, mainly during April and early May, have been recorded. These whales have been noted to be feeding, and they only remain in the area for a few days or weeks. Sightings of Right Whales near Cape Cod have also been recorded in late summer and early autumn. Right Whales also occur seasonally (summer and early autumn) in the Gulf of Main, the lower Bay of Fundy, and points further north. These more northerly areas are important feeding grounds for Right Whales.

General Biology

Due to the rarity of the species, little or nothing is known of its reproductive rate and other population and life history parameters. Neither is much known of the relationships of the Right Whale to its environment. It appears to be specialized in its feeding habits, taking copepods preferentially over other possible foods (Mitchell 1975).

Limiting Factors

Although the number of sightings and strandings of Right Whales has increased during the last ten years, observer effort may have increased proportionately (Reeves, Mead and Katona 1978). These authors list and discuss several factors which may be limiting recovery of the population:

1. *Depletion* to below some critical population size.
2. *Predation by Killer Whales* (*Orcinus orca*) — probably not important.
3. *Competition.* Mitchell (1975) believed that Right Whales and Sei Whales (*Balaenoptera borealis*) were sympatric, both preferring copepods as prey and resorting to euphausids as a second choice. Since the Right Whales were close to extinction before the end of the 19th century, and before the balaenopterid whales were exploited, it is possible that Sei Whales proliferated in the western North Atlantic and the Right Whales declined, the former, displacing Right Whales and inhibiting their recovery (Mitchell 1975).
4. *Loss through entanglement of individuals in fishing gear.* Reeves, Mead and Katona (1978) report a Right Whale entangled in the lines of lobster traps off Long Branch, New Jersey, on 1 July 1976. This whale was apparently successfully released, and a similar-sized animal was seen about three weeks later near Ocean City, New Jersey, with strands of rope hanging off it. Reeves et al. (1978), in addition, mentioned two Right Whale entanglements as probably exceptional. However, they point out such entanglements could be potential hazards to individual whales and thus prevent further stock recovery.
5. *Increased water turbidity.* Right Whales may depend largely on vision to avoid obstacles and find food; therefore, increased turbidity in the water column, due to industrial activity and offshore dumping, could pose a serious problem for Right Whales in eastern North American coastal areas.
6. *Noise.* Human-generated noise may interfere with communication among Right Whales.
7. *Pollution.* Oil Spills could be disastrous to Right Whales since they commonly feed by skimming through swarms of zooplankton at or near the surface. Coastal pollution from the northeastern United States may also have deleterious effects upon seasonal Right Whale populations. Ocean dumping of sewage and industrial wastes is extremely heavy along this coast. Some potential pollution threats to whales include heavy metals, chlorinated hydrocarbons, and various industrial metals. Reeves et al. (1978) state: "In a badly reduced, slow-reproducing species like *Eubalaena*, for which survival of every offspring is critical, any adverse effect of pollutants could be highly exaggerated."

Special Significance of the Species

As numbers of this species are extremely low, it has received special attention from the IWC and CITES; its profile is therefore, inversely related to its scarcity, and conservation groups in Canada and abroad are monitoring the action of governments with respect to its protection.

Evaluation

In spite of protection during the last 50 years or so, Right Whales remain few in number and do not appear to demonstrate any substantial degree of population recovery. Further study of the Right Whale and its ecological relationships may aid the development of management plans to improve the chances for its survival and recovery.

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Status of the St. Lawrence River Population of Beluga, *Delphinapterus leucas**

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Pippard, L. 1985. Status of the St. Lawrence River population of Beluga, *Delphinapterus leucas*. Canadian Field-Naturalist 99(3): 438–450.

The Beluga or white whale population of the St. Lawrence River comprises Canada's most southern concentration of this otherwise arctic species, their presence in the river made possible by the waters of the St. Lawrence Estuary being of cold arctic type. The population is considered geographically isolated from northern stocks. The size of the population has gone from "many thousands" before 1949 to 1500 in the 1960's to 500 in the early 1970's to 350 in 1978. The majority of Belugas are located between Les Escoumins and Ile aux Coudres and Rimouski and Rivière Ouelle, Quebec. Both the population's size and habitat are severely reduced from historic levels. Over-exploitation and disturbance of habitat are regarded as the main factors having caused past decline, while direct and indirect interference, environmental contamination and intraspecific competition are theorized as factors possibly contributing to the present decline. The St. Lawrence Belugas are protected from hunting and some forms of disturbance; their habitat is presently unprotected. Further protection of both the animals and their habitat is regarded as essential in aiding the stocks' survival.

Le fleuve St-Laurent constitue la limite méridionale de l'aire de répartition du béluga ou baleine blanche, une espèce qui peuple habituellement les eaux arctiques. Sa survie dans le fleuve est rendue possible par le fait que les eaux de l'estuaire du St-Laurent sont froides comme celles de l'Arctique. On considère cette population comme géographiquement isolée des stocks septentrionaux. Le nombre est passé de "plusieurs milliers" avant 1949 à 1 500 baleines dans les années 1960, à 500 au début des années 1970 et à 350 en 1978. La majorité des bélugas du fleuve St-Laurent vivent entre Les Escoumins et l'île aux Coudres, et entre Rimouski et Rivière-Ouelle (Québec). Tant la population que les habitats disponibles ont diminué de façon considerable. La surexploitation et la perturbation de l'habitat sont considérés comme les facteurs principaux ayant entraîné la déclin passé, tandis que l'interférence directe et indirecte, la contamination de l'environnement et la compétition intraspécifique constituent des facteurs hypothétiques qui pourraient contribuer au déclin actuel. La chasse du béluga est interdite dans le St-Laurent, de même que certaines formes de harcèlement, mais son habitat n'est actuellement pas protégé. On considère qu'il est essentiel de protéger davantage ce mammifère et son habitat afin de favoriser la survie de ce stock. [Traduit par R. R. Campbell]

Key Words: St. Lawrence River, Beluga, *Delphinapterus leucas*, white whale, population size and trends, endangered.

The Beluga (*Delphinapterus leucas*), is a robust, medium-sized white whale with a rounded prominent forehead and a ridge on the back in place of the dorsal fin (Figure 1). The name *Delphinapterus* means "dolphin without a fin". The Beluga are 'toothed' whales reaching a maximum length of 5.5 metres and a weight of 1.6 tonnes. Males are usually longer than females and the flippers of older males show a marked upward curve at the tips. A noticeable constriction at the back of the head gives the animal a feature that can only be described a neck, and indeed the Beluga has more flexibility with regard to lateral movement of the head since the cervical vertebrae are not fused as in most other cetaceans. Adult Beluga are all white except for the trailing edge of the flukes which may be grayish. At birth, the calf is a dark brown which soon changes to a bluish gray. As the animal matures, the colour lightens until at about the sixth year they attain the white adult colouration. The unique colouration makes it impossible to confuse this species with any other and the name Beluga is said to come from the Russian *byely* for white.

These whales are residents of the Arctic and Subarctic seas, and usually travel is pods of two to 10, but groups of 100 or more are not uncommon.

Distribution

The Beluga is a large dolphin which occupies a circumpolar range. Of the several North American populations, summarized in Table 1 and illustrated in Figure 2, the population inhabiting the St. Lawrence River comprises Canada's most southern concentration of this species.

White whale skeletons unearthed from Pleistocene clay and sand deposits at Cornwall and Smith's Falls, Ontario; Montreal, Quebec; and Charlotte, Vermont (Ardley 1916), reveal that 11 000 years ago Beluga had an extensive distribution made possible by the Champlain Sea. With the retreat of this sea, the Great Lakes and St. Lawrence River took on their present dimensions between 3 000 to 8 000 years ago. Within the St. Lawrence estuary, Basque whalers and French

*Endangered status approved and assigned by COSEWIC 6 April 1983.

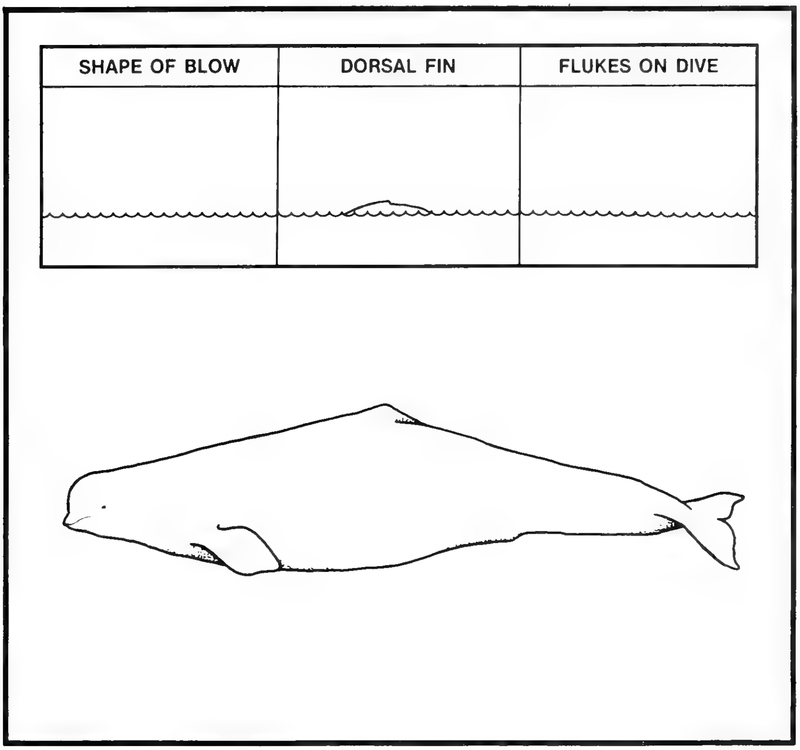

FIGURE 1. The Beluga or "white" whale, *Delphinapterus leucas*.

explorers in the 1500's (Belanger 1971; Chambers 1912), and French settlers in the 1800's (Casgrain 1873) noted a great abundance of white whales.

The first extensive investigation on the St. Lawrence Beluga was undertaken by Vladykov in 1938. He reported white whales were regularly present between Baie-Trinité and Natashquan; in Baie des Chaleurs, 30 miles above Quebec City, and at Chicoutimi in the Saguenay river (Figure 3). Within this broad range Vladykov (1944) outlined the annual concentrations from Ile-aux-Coudres to Rivière-Ouelle to Cap Chat on the south shore, with large summering concentrations to be found at the mouths of the Saguenay and Manicouagan Rivers.

No subsequent extensive study of the population was made until the 1970's when Pippard and Malcom (1978) described the Beluga's current distribution. They reported that white whales are observed occasionally along the Gaspé Peninsula, but very rarely at Quebec City, Chicoutimi and Baie Comeau. They are presently most common (Figure 4) from Ile-aux-Coudres to Les Escoumins on the north shore of the St. Lawrence, and Rivière-Ouelle to Rimouski on the south shore, with one summering concentration occurring at the mouth of the Saguenay River. Their surveys affirmed Sergeant's observation (Sergeant and Brodie 1975) that the large concentration of white whales sampled by Vladykov (1944) at the mouth of the Manicouagan and Outardes Rivers has disappeared. In all, this reveals a marked decrease in the St. Lawrence white whales' distribution from 40 years ago.

Evidence for Geographic Isolation

The restricted distribution of the St. Lawrence Beluga suggests they are isolated from eastern Arctic Beluga concentrations, thereby forming a geographically distinct stock. The most likely passage for Arctic Beluga immigrants into the Gulf of St. Lawrence would be through the Strait of Belle Isle. Vladykov (1944) mentioned this was an area where Belugas were only observed once, in 1931 or 1932, when a large herd was sighted at Vieux Fort. He speculated that this unusual occurrence might have been due to an influx of Belugas from West Greenland. It is just as likely however, if not more so, that the sighting was of a herd of Belugas from the St. Lawrence, perhaps wandering further from their general zone of concentration than usual. Vladykov (1944) found no specific information

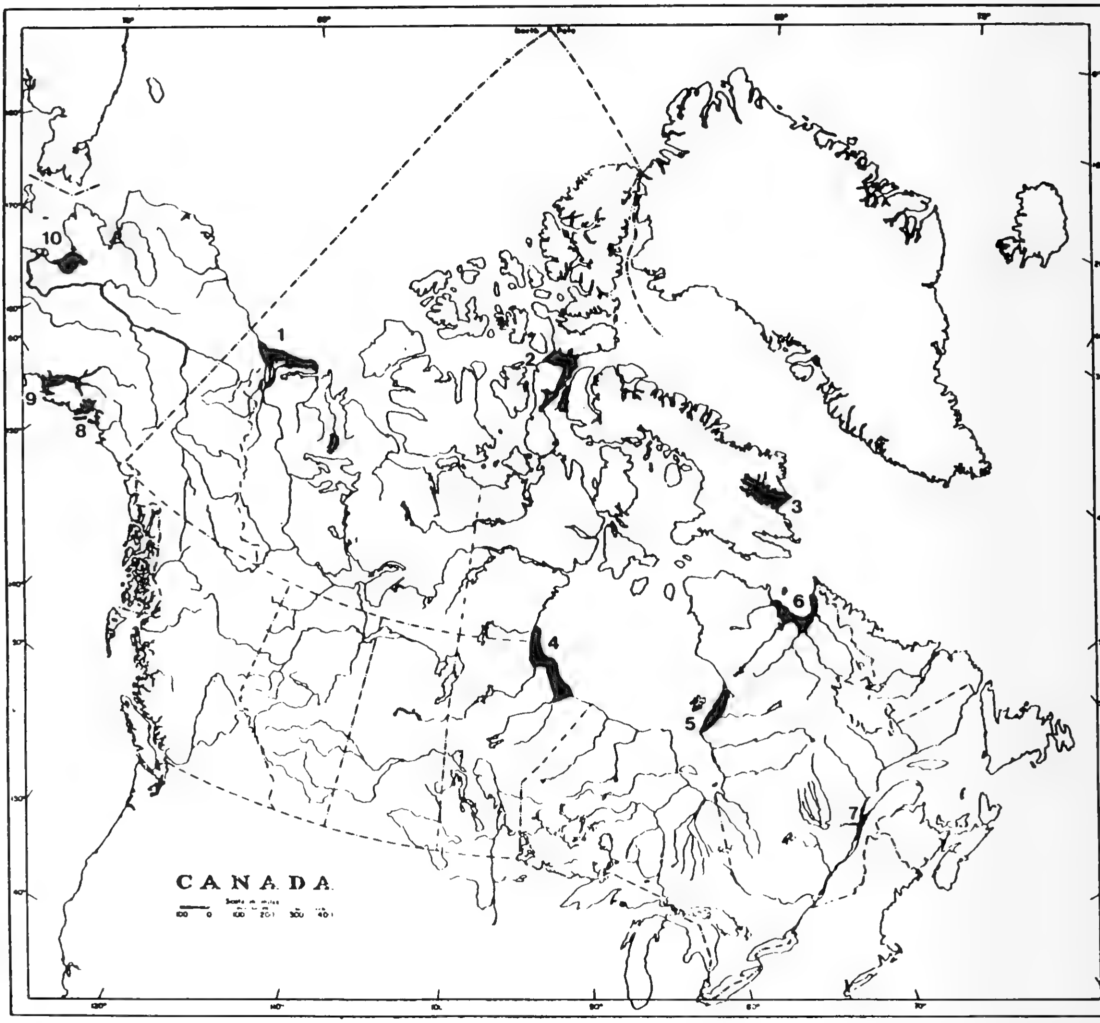

FIGURE 2. Distribution of the Beluga, *Delphinapterus leucas*, in Canada and Alaska. The numbers relate to the populations as numbered in Table 1.

on the number of Belugas to be found along the coast of eastern Labrador and Newfoundland and assumed that there were few there.

Sergeant (1962) and Sergeant and Brodie (1975) reported that Beluga were rarely observed along the eastern Labrador and Newfoundland coasts. In the summer of 1981, two Belugas were sighted near Blanc Sablon (Pippard, unpubished data); however, this sighting was regarded as unusual by residents who pointed out Belugas were not normally seen at this locality. Sears (personal communication) reported observing no Belugas in the Strait of Belle Isle on his recent aerial surveys to locate baleen whales.

Both Brodie (1971) and Finley et al. (1981) have found that the respective populations in Cumberland Sound and Ungava Bay have been severely depleted from historic levels by over-hunting. The reductions indicate that these stocks have not received recruits from other eastern Arctic Beluga populations. Population reduction from over-hunting has also occurred in the St. Lawrence River population, suggesting that this stock has not received recruits from Arctic populations.

White whales reported from the Maritimes and the northeastern United States (Sergeant, Mansfield and Beck 1970; Reeves and Katona 1980), are probably immigrants from the St. Lawrence rather than the Arctic, because most of these sightings occur in late

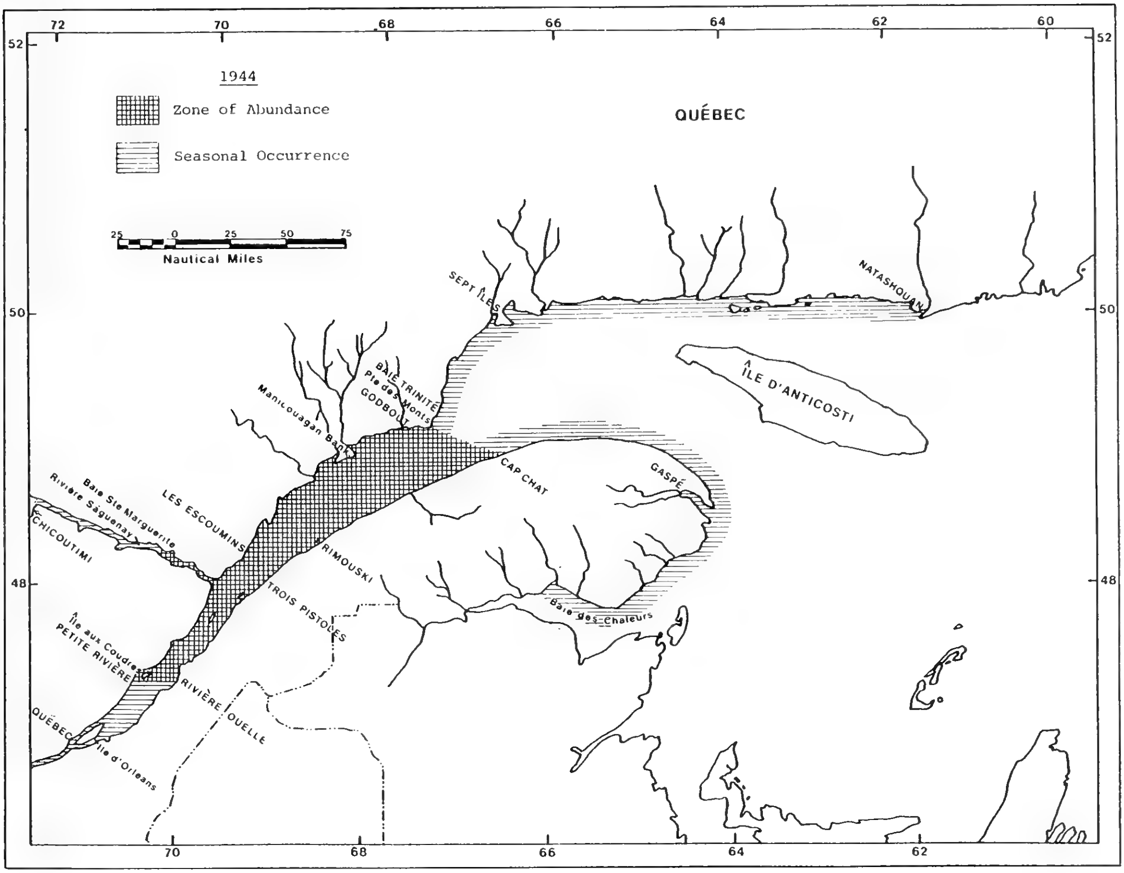

FIGURE 3. Former distribution of the Beluga, *Delphinapterus leucas*, in the St. Lawrence River and Gulf (from Vladykov 1944).

winter and spring when the St. Lawrence Belugas occur down the estuary as far as the Gaspé coast.

In summer, the lack of sightings of Beluga off the eastern coast of Labrador, the rarity of their occurrence in the Strait of Belle Isle, and the fact that the St. Lawrence population is severely depleted from historic levels, represent the best evidence that this stock is geographically isolated.

Protection

Belugas are protected and managed under the Fisheries Act of Canada of 1867. The amendment of 1976 provides for habitat protection for all species of fish and whales. Further protection was afforded the species in 1979, under the Beluga Protection Regulations of the Fisheries Act. Prohibition of International trade has been ensured by the listing of all cetacea on Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Belugas are now hunted in Canada only by the Inuit for subsistence purposes.

Prior to 1979, no government regulations covered the St. Lawrence white whale stock. Consecutive low population counts by Sergeant (1973) and Pippard and Malcom (1977), plus the latter authors' knowledge that the population was being sporadically hunted and harrassed, led the Department of Fisheries and Oceans in March 1979 to add the St. Lawrence Beluga to the Beluga Protection Regulations of the Fisheries Act. Amended in December 1980, this act presently outlaws all forms of hunting and killing, chasing and willful disturbance of this population.

Population Size and Trend

Historic anecdotes and records of past catches support the assertions of hunters, fishermen and coastal residents that there were once some thousands of white whales in the St. Lawrence River. A white whale

fishery that thrived along the St. Lawrence River between the late 1500's and the early 1900's, is suspected of having caused a signficant reduction in the original stock. Removals, such as those recorded for the whaling community of Rivière-Ouelle, where 300 to 500 Belugas were caught on a single tide in the 1870's and 1800's, during the summer months (Casgrain 1873), likely far exceeded the Beluga's annual herd production. Indicative that decline resulted due to over-exploitation is Vladykov's report (1944) that catches for both Rivière-Ouelle and Ile-au-Coudres were far fewer in the period 1929-1944, dropping to as low as 15 per year.

Around 1870, l'Abbé Casgrain (1873) spoke of the enormous numbers of these animals at Rivière-Ouelle, noting that as many as 1800 were caught in a good season, while in 1929, St. Lawrence fishermen were complaining that the large number of Beluga were responsible for their decreased catches of commercial fish (Vladykov 1944).

Responding to the fishermen's complaints, the Quebec fishery department initiated a Beluga bounty hunt that lasted from 1932 to 1938. An average of 323 white whale bounties were paid each year, with a total removal of 2 235 whales from the population during the period.

No estimate of the size of the St. Lawrence stock following the bounty hunting years was given by Vladykov (1944), although he must have felt that the population's size was still considerable to recommend a better organized commercial hunt that could take as many as 1 000 Belugas per year.

Depressed prices for white whale oil and hides brought the commercial hunt to a close in the 1940's. Sporadic hunting for local consumption continued, but unfortunately, there are no further statistics available until the years 1956-58 inclusive, during which period, 15 whales were taken (Mitchell 1975).

In the early 1960's an aerial survey conducted by the Quebec Aquarium produced an estimate of 1 200 to 1 500 white whales between Quebec City and Les Escoumins (P. Montreuil, personal communication). Harold Smyth, a former vessel owner who was aboard many of his ship's cruises in the St. Lawrence River and Gulf during the 1960's, estimated that in the late 1960's, there were between 1 200 to 1 500 white whales throughout the river (personal communication); but by 1972, only 700 were present. Aerial surveys conducted by Sergeant and Hoek in 1973, produced an estimate of 500 to 1 000 white whales for the St. Lawrence estuary (Sergeant and Brodie 1975), though Sergeant's actual observed count was only 370 (unpublished data).

Of the 12 aerial surveys conducted by Pippard and Malcom in 1975 and 1977, eight were carried out during summer months within the area defined as the white whales' summer zone of concentration, while the remaining four covered respectively the coastal waters of the St. Lawrence from Grandes Bergeronnes to Sept Iles (October 1977), Cacouna to Rimouski (July 1977), Ile aux Lièvre to Iles-aux-Coudres (November 1977), and the Saguenay River from Alma to Tadoussac (July 1977). Their repeated coverage of a fairly restricted area was based on their findings of the limited distribution of the St. Lawrence Beluga during summer months. Moreover, their extensive tracking of Beluga by boat revealed that the whales are not haphazardly dispersed within their summer area, but are concentrated in specific localities that they make regular use of throughout the summer. In consequence, random stratified aerial survey design was not used, but instead the surveys covered as many of the Beluga's known specific habitats as was possible during each of the flights. On 6 and 22 July 1977, all of the Beluga's identified habitats plus the major portion of those water areas lying between and outside these key areas, were successfully surveyed. On these two flights, 262 and 266 whales, respectively were counted, which were the highest numbers recorded for all the flights completed. On the four coastal surveys outside the summer zone of abundance, 33 Belugas were observed. When allowance is made for the occurrence of animals outside the summer distribution zone, plus the tracking and aerial observations of maximum herd sizes, the population is estimated to be higher than 300 whales, but fewer than 350.

In the summer of 1981, the Department of Fisheries and Oceans followed up these flights using a similar survey method. Several bi-weekly flights were conducted, the highest observed count from which was 240 Belugas (R. G. Greendale, personal communication).

As no one has yet employed a statistically rigorous survey of the St. Lawrence Estuary and confidence limits for the population cannot yet be established, the order of magnitude of the stock in the low hundreds is not disputed. The population is clearly declining, a trend which has been taking place over many years.

Habitat

Typical Habitat

Throughout their distribution range Belugas inhabit cold Arctic waters, living amongst ice in winter and in shallow bays and estuaries of large northern rivers in summer.

Even though the St. Lawrence River is not located in an Arctic environment, the waters in its lower estuary are of Arctic type, their low summer temperature resulting from a process of *in situ* winter cooling (Forrester 1964) that allows planktonic species with dis-

tinctly Arctic affinities to thrive here plus true Arctic species such as the Greenland Shark (*Somniosus microcephalus*) and the Beluga. The St. Lawrence River also meets the second apparent habitat requirement of the Beluga: the estuary is fed by numerous large rivers, its major freshwater sources being the Saguenay, Bersimis (or Betsimites), Manicouagan and Outardes Rivers.

Critical Habitat

Within the St. Lawrence estuary, Beluga concentrate in specific areas year after year. These areas are for one or more activities: socializing, feeding, breeding, calving, resting and travelling. These areas are considered to be essential to the species' survival and can be referred to as "critical" habitat.

From observations collected during two summer and fall seasons in 1975 and 1977, Pippard and Malcolm (1978) described nine critical habitats used by the St. Lawrence Beluga. These areas have been defined by the use made of the Saguenay and St. Lawrence Rivers by three recognized assemblages within the population:

i. *Female Herds*: Congregations in which more than 60 per cent of individuals are in groups, consisting of breeding females and their offspring.
ii. *Adult Herds*: Congregations in which more than 60 per cent of the individuals are in adult groups, groups consisting of predominantly adult males with some older immature males, and single adult females.
iii. *Mixed Herds*: Congregations in which there is approximately equal representation from groups of females and young and adult groups.

What is clear from the observations is that preferential, but not exclusive use, of certain habitats occurs by either groups of females and young, or adult groups.

Females accompanied by juveniles favour the areas of Ile aux Lièvres, Basque Road (Anse aux Basque), Baie Ste. Marguerite, Baie Ste. Catherine, Ilet Rouge and Prince Shoal (Recif aux Prince) [Figure 4]. These areas are generally characterized by:

— shallow water (2-18 m) having relatively warm surface temperatures ranging from 6 to 10° C;
— sand, gravel, and mud bottoms supporting molluscs, crustacea, marine worms and bottom fish such as Sculpins (*Cottus sp.*), Tomcod (*Microgadus tomcod*) and Sandlance (*Ammodytes americanus*), all items which female Beluga are known to eat (Vladykov 1944);
— relatively calm water, sheltered from mixing and upwelling zones, tide rips and fast currents.

These conditions are found along protected reef and island edges and in large bays. Owing to the high frequency of use given to these six areas by females and their young, all can be regarded as critical habitat.

It was also observed that about half the population of adults and weaned young used the female and young habitats regularly, while the other half concentrated in Northeastern Ilet Rouge and Grandes Bergeronnes areas. These areas are characterized by:

— abrupt changes in water depth (24 to 180 m), having cold summer surface temperatures of 2-6° C, and sub-surface temperatures of 0-1° C;
— reef bottoms of sands and gravels, deep bottoms of pelite, calcipelite, sandy muds and coarser materials;
— upwellings, vertical mixing, rip and counter currents, and internal tides on the rising tide;
— relative calmness on the slack phase of the tide.

Females and young were found rarely in either Northeastern Ilet Rouge or Grandes Bergeronnes areas during the summer. It is believed that they avoid them in order to protect newborn from excessive heat loss in the cold.

The Saguenay mouth (Figure 4) was the habitat most frequented by mixed herds, and is identified as a major feeding area for Belugas during the summer and fall. The area's most important physical feature is a shallow sill (12-36 m) extending across the entrance of the Saguenay River. On rising tides, turbulent tide lines are created as the flood waters push against the strong freshwater outflow upwelling from depths of 200 metres. It was during this time that white whales were regularly observed energetically criss-crossing the area, apparently engaged in feeding.

Of the two remaining critical habitats, Prince Shoal was used principally as a travelling area by all herds. Occasionally Belugas were observed feeding from the Saguenay mouth over this Shallow reef area. However, during intense phases of rip currents on ebb tides and upwelling on rising tides, Belugas avoided the area (Pippard, unpubished data).

Ilet Rouge habitat was named after the islet which is formed from the exposed portion of a reef lying in mid-channel, off the mouth of the Saguneay River. This area encounters strong rip currents on ebb tides and intense vertical mixing on flood tides. It is during floods that a distinct tide line extends on a southwest to northeast diagonal through this area, as well as along the outside edge of Basque Road. This line, consisting of a continuous strip of disturbed water formed by the meeting of the flood tide and the outflow of the St. Lawrence, attracts groups of Belugas, Minke Whales (*Balaenoptera acutorostrata*) and seabirds, which are frequently observed feeding. Ilet Rouge is apparently used slightly more by groups of females and young than groups of adults. Resting of individual animals and groups has been observed here on calm phases of the

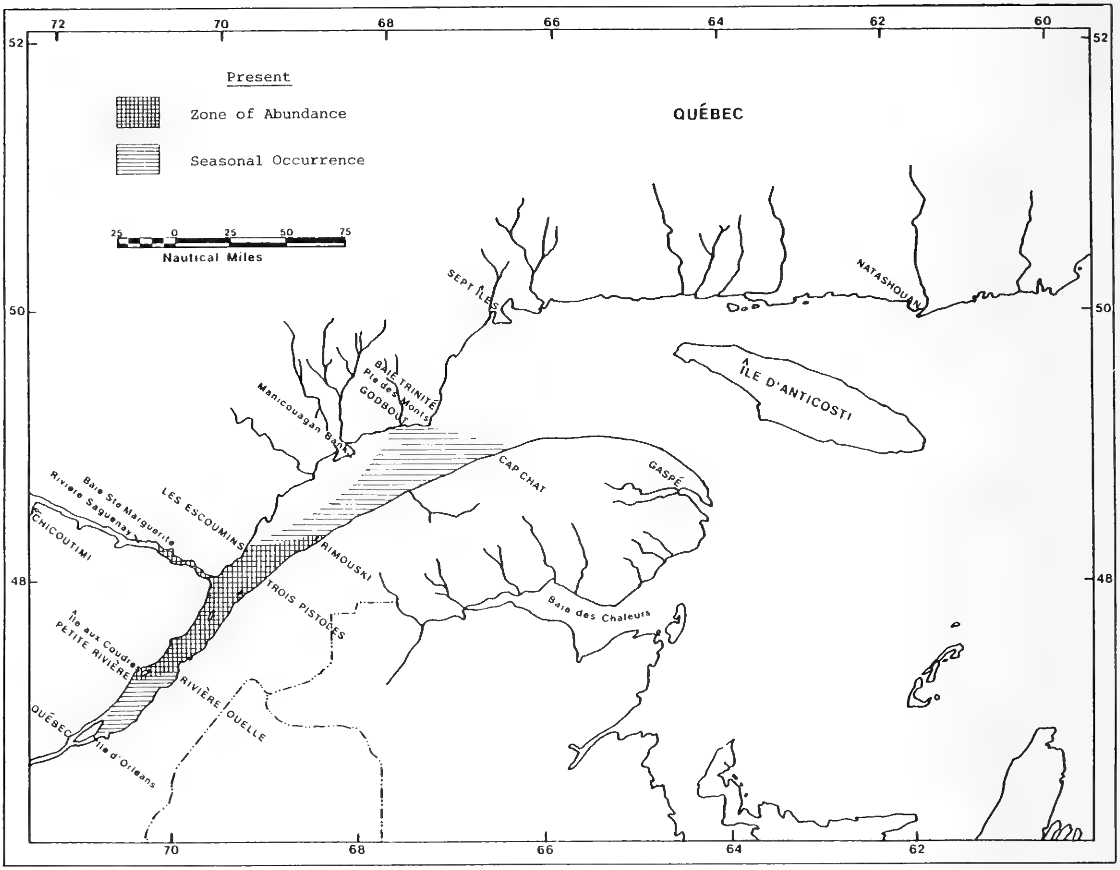

FIGURE 4. Present distribution of Beluga in the St. Lawrence River and Gulf (from Pippard and Malcolm 1978).

tide. As well, Ilet Rouge has been found to serve as a travel corridor for groups passing back and forth between habitats upstream and downstream of the Saguenay River.

Changes in Amount of Critical Habitat

The amount of critical habitat available to the St. Lawrence Beluga has undergone severe reduction. This is mainly a result of the loss of the combined Manicouagan and Outardes river mouths (*see* Limiting Factors), which until the 1960's were a major summer congregating area for the white whales.

Within the remaining area of critical habitat, one locality of former importance is known to no longer be used in the summer; this is Baie Tadoussac at the mouth of the Saguenay River.

Changes in Quality of Critical Habitat

Quality of the Belugas' critical habitat has deteriorated in recent years as a result of extensive municipal, agricultural and industrial pollution discharged to the St. Lawrence and Saguenay Rivers and their tributaries from the many urban centres concentrated in the St. Lawrence drainage basin.

Mercury released from chloralkali plants and pulp mills at the head of the Saguenay Fjord has resulted in particularly high concentrations in sediments of the Saguenay River, downstream into the estuary of the St. Lawrence (Loring 1975). There are also high concentrations of mercury in commercial fish in the estuary and Saguenay River (Bligh 1970; Tam and Armstrong 1972). Mercury levels in certain species of shellfish, such as shrimp, clams and mussels, have reached high enough levels for the government to post notices throughout the region warning the public not to eat the shellfish.

With shipping annually increasing on the St. Lawrence and Saguenay Rivers, there has also been an increase in incidences of oil spills, although better surveillance and steeper fines are apparently reducing the number of ships purposely discharging bunker oil into

the water environment.

Rate of Habitat Change

Since the 1950's, there has been a 30-year period of phenomenal growth in Quebec's resource-based industries that has seen the development of international shipping ports at Sept Iles, Port Cartier and Baie Comeau, construction of the Manicouagan hydroelectric project and the opening of the St. Lawrence Seaway. While direct cause and effect relationships (in terms of habitat change) cannot be proven, these certainly could not have had positive or neutral effects on Beluga habitat.

General Biology

Reproductive Capability

The mean ages at sexual maturity for Arctic populations have been determined by Brodie (1971) and Sergeant (1973) as five years for females and eight years for males. It should be recognized however, that aging Belugas based upon tooth layering is not very reliable (Davis 1981). Breeding frequency was determined by the same authors to be every three years on the average. Only one young is born at a time. Belugas are considered to be polygamous, but nothing is known of their reproductive behaviour as little research has been conducted.

Sergeant (1973) determined a reproductive rate of 15 per cent for Western Hudson Bay Belugas, while Brodie (1971) estimated 10 per cent for Cumberland Sound Belugas, but reduced this to 8 per cent to take into consideration first year mortality. He now feels 8-8½ per cent is likely to be the maximum reproductive rate for Beluga (P. F. Brodie, personal communication).

Growth potential under optimum natural conditions is not known for this stock.

Species Movement

St. Lawrence Beluga migrations correspond to the seasons with water temperatures, freshwater discharge and areas of water turbulence considered to be important natural factors influencing their movements. Spring, fall and winter are the seasons of population dispersal in the St. Lawrence River while summer is the season of white whale concentration (Pippard and Malcolm 1978).

In March and April, some scattered groups of Belugas are found along the Gaspé Peninsula. Most, however, are found from late March to early June, between Rimouski and Rivière-Ouelle on the south shore of the St. Lawrence, and between Les Escoumins and Ile-aux-Coudres on the north shore. Their tendency to be found further east towards the Gulf in early spring indicates they may be foraging on the large spring runs of herring and Capelin (*Mallotus villosus*) that are entering the estuary to spawn.

During June, July and August, the major portion of the population is concentrated around and in the Saguenay River, with few Belugas found either upstream of Kamouraska and St. Simeon or downstream of Les Escoumins and Trois Pistoles. Fish concentrations are abundant in this area in summer. Here also, female Belugas are thought to take advantage of the numerous shallow warm water bays, reef and island edges to bear and nurse their young.

In September, Belugas are observed less frequently in and around the Saguenay River, yet return to the river again in October and November. In fall, Belugas are seen along the Gaspé, as well as much further upstream, to as far as Ile d'Orléans. The appearance of Belugas at such localities as Rivière-Ouelle and Pétit Rivière Ste. Francois, coincides with colder autumn water temperatures plus Smelt (*Osmerus mordax*) and Eel (*Anguilla rostrata*) runs throughout the upper estuary, both of which are eaten by Belugas. By late October and early November, scattered groups of Belugas are reunited into large herds that can be found either downstream of the Saguenay River or at Ile aux Lièvres.

Recent winter observations of Belugas show that they spread down the estuary from the Saguenay

TABLE 1. Populations of Belugas in Canada and America

Area (Map No.)	Number	Observer
MacKenzie River Delta (1)	6 600	Fraker (1978)
Lancaster Sound (2)	4 000	Sergeant, Hoek (1974)
Cumberland Sound, Baffin Is. (3)	few hundred	Brodie, Sergeant (unpublished data 1979/80)
Western Hudson Bay (4)	10 000	Sergeant (1973)
Eastern Hudson Bay (5)	few hundred	Breton-Provencher (1979)
Ungava Bay (6)	less than 100	Finley et al. (1981)
St. Lawrence Estuary (7)	300–350	Pippard, Malcolm (1978)
Alaska		
Cook Inlet (8)	150–300	Fay (1974), Fish and Vania (1971)
Bristol Bay (9)	1 000–1 500	Johnson et al. (1966)
Norton Sound/Yukon River (10)	unknown members	Harrison and Hall (1981)

River in January and February. These sightings show the same two areas of winter concentration as reported by Vladykov (1944); one off the mouth of the Saguenay River and the other between Godbout and Pte. des Monts. Both these areas, which seem significant to the survival of Belugas, have strong currents that keep the water relatively ice-free, and harbour over-wintering fish concentrations.

Amongst all Beluga herds, groups and individuals, there also occurs considerable daily movement as they move from habitat to habitat. Much of this daily movement is assumed to be connected with feeding.

Behaviour/Adaptability

Beluga, having evolved a well-developed and sensitive system of hearing and echolocation to assist them in foraging for food, navigation and communication with one another, demonstrate obvious responses to pronounced in-water or air-borne sounds.

Pippard and Malcolm (unpublished data) have noted entire Beluga herds deep-diving long before a fast-moving speed-boat is actually near them, suggesting to them that the Belugas are removing themselves as much from the noise of the boat as from its presence. They have also found, as have Hay and McClung (1974), Sergeant and Hoek (1976) and Finley et al. (1981) that Belugas are sensitive to noise from aircraft flying at low altitudes.

Also assumed to greatly affect Belugas is underwater dynamiting which was observed in 1979, during ferry terminal expansion. If Belugas are in the proximity of such blasts at the time they occur, it appears likely that their hearing could be significantly impaired, and if they were close to the blast, it is possible that death could result.

Belugas also show a limited tolerance to chasing and hunting disturbance. Vladykov (1944) stated that Belugas chased by a motorboat tire quickly, within 10 to 15 minutes. Pippard and Malcolm (1978) noted a group of Belugas chased by a motorboat for over 20 minutes showed fatigue and panic by not being able to stay submerged for normal dive durations and by losing their group coordination and colliding with one another.

By contrast, Pippard and Malcom (1978) noted that Belugas demonstrate much less reaction to ferries, ships and sailboats that pass by them, merely swimming out of their paths or casually diving deep to pass under them.

It is when disturbances are not only pronounced, but occur on a regular basis or for long durations, that Belugas seem more apt to leave an area. Vladykov (1944) noted that individual Belugas that had been chased before became increasingly timid and in time would avoid places frequented by hunters. Finley et al. (1981) mentioned that Belugas temporarily vacated habitat due to hunting disturbance. Ford (1977) found that white whales uniformly reacted and avoided an area of up to 2400 m (1.5 miles) from either side of the track of a moving barge and tug during construction of an artificial island in the Beaufort Sea.

Belugas, however, also often display tenacity in using certain areas despite disturbances. In Fraker's overall conclusions on Beluga, he noted that minimal long-term effects from barge traffic are noticeable (Fraker 1976-1980). Also Pippard and Malcolm (1978) found that females with young, while normally taking the greatest pains to avoid disturbance when travelling from area to area, were highly reluctant to leave such favoured habitats as Baie St. Marguerite or Basque Road, despite boating disturbance. Instead they removed themselves within the habitat as far away as possible from the boats. Also, Belugas were less likely to heed disturbance when engaged in group feeding, but would vacate an area quickly if disturbed from group resting.

From the foregoing, it is possible to say only that various kinds of noise-related disturbances affect Belugas, but that obvious effects are short-term. Long-term effects such as abandonment of habitat of young, or acoustical impairment have not been recorded (with the possible exception of Baie Tadoussac); indeed Beluga return to areas of previous harassment. However, nothing is known about long-term reproductive, behavioural or physiological changes brought on by chronic noise related problems. In this regard, the Beluga's apparent propensity to return to the same area leaves it vulnerable to continuing exposure to these factors.

Limiting Factors

The decline of the St. Lawrence Beluga would appear to be mostly due to historic over-exploitation and recent alteration of habitat. As outlined previously, hunting for these animals has occurred since the late 1500's. There is good evidence that significant declines in the stock have occurred due to over-exploitation during those years. Sporadic hunting, mainly for limited local consumption, continued on the stock into the 1970's. The number of animals removed by this activity between 1940 and 1975 is unknown. However, from 1975 to the present, with the cessation of hunting, this activity has not been found to be a cause for the stocks' decline, though it has been a factor reducing its growth.

A serious limiting factor in recent years has been the loss to the Belugas of the estuaries of the Manicouagan, Outardes and Bersimis Rivers. Vladykov (1944) noted that the largest concentrations of Belugas in the St. Lawrence River occurred between the mouths of the Manicouagan and Bersimis Rivers from May

through to October. As Belugas seek out such freshwater river estuaries for calving and feeding purposes, it appears these three large northern river mouths once constituted major critical habitats for St. Lawrence Beluga. All three of these rivers are extensively dammed, the Bersimis in the 1950's, followed by the Manicouagan and Outardes Rivers in the early 1960's. Manicouagan Peninsula residents report both the Sturgeon (*Acipenser oxyrhynchus*) and large herds of Belugas disappeared from the Manicouagan Bank in the early 1960's. This parallels with the primary construction phase of the Manicouagan power complex. Some Sturgeon are again reported for the area, but the white whales have not returned (Pippard and Macfarlane 1980, unpublished data).

The local residents consider that excessive suspended solids in the mouths of the Manicouagan and Outardes Rivers, produced by the dam blasting, drove the Sturgeon and Belugas away. However, this is unlikely in view of the high sediment loadings in the Mackenzie river estuary which is utilized by several thousand Belugas annually. Sergeant and Brodie (1975) suspect the dams' major alterations to the rivers' overflow also drastically altered the heat budget, possibly making the water temperatures on the Manicouagan Bank too low or unreliable for Beluga calving.

Pippard and Malcolm (1978) speculated that these same alterations might have adversely affected fish and invertebrate reproduction areas on the bank, thereby reducing the number of prey species available to Belugas, thus forcing their abandonment of this major habitat. Substantiating their view is growing evidence of significant reductions in aquatic invertebrates downstream of reservoirs (Lehmkuhl 1972; Fisher and LeVoy 1972; Luedtke and Brusven 1976; Lehmkuhl 1979; Nehuhoff 1979) plus evidence that lowered temperature and salinity (such as occurs downstream of reservoirs in summer) can affect adversely fish production and growth rates in such coastal spawning fish as herring, Capelin and sole (Jean 1967; Parent and Brunel 1976; Fonds 1979), all of which Belugas are known to eat (Vladykov 1944).

Depending on whether or not Rivière-Ouelle/Ileaux-Coudres region was also historically a significant summer concentration area for Belugas, the loss of the Manicouagan Bank represents a reduction amounting to either one half or one third of the Beluga's available critical summer habitat in the St. Lawrence River.

Although cause and effect are not as evident for other areas, the gradual disappearance of Belugas from such seasonally used habitats as Quebec City and Chicoutimi probably stems from degraded water quality and reduced productivity in these regions due to harbour dredging and filling, increased shipping, port terminus expansion and, thermal and chemical water pollution.

More recently, Belugas have stopped using Baie Tadoussac, which lies within the mouth of the Saguenay River, in summer. According to many local residents, up until the 1970's, white whales had used this bay for as long as anyone could remember and, in fact, their regular summer occurrence in it had made them one of the village's more renowned visitor attractions. In the early 1970's, a pleasure-craft marina was built in the bay and later expanded resulting in a substantial increase in the number of small motorized craft entering and leaving the harbour during the summer months. While sailing ships, trading canoes and freight and passenger steamers of former years apparently did not overly disturb the white whales, it appears that the amount of motor-boat disturbance now associated with the harbour may have led to the abandonment of this area.

Baie Tadoussac does not represent loss of habitat on the scale of the Manicouagan Bank, but this area has all the characteristics of an area favoured by females and young and might have received significant use by them. It highlights the insidious nature of incremental habitat loss — each development on its own removes a relatively small amount; but, when summed, the losses are large.

Concern is presently mounting in Baie Ste. Marguerite, a critical habitat where calving, nursing, resting, benthic feeding and possible breeding are thought to occur, but also where growing use of the bay by boaters is making it increasingly diffcult for the white whales to continue to utilize the area.

When disturbance, in whatever form, reaches proportions that induce panic, habitat abandonment or continual evasive action, it is also likely that increased energy consumption and stress on the animals is also occurring, which in turn could be affecting their reproductive fitness or survival. Further, if one assumes that the use by Belugas of traditional areas and seasonal ranges contributes to their biological viability, their reduced use or abandonment of these areas due to disturbance acts as a serious limiting factor on the population's prospects for growth and survival.

In addition to past over-exploitation and current or recent direct and indirect disturbance, other factors which may be contributing to the population's decline, but about which little is known at present, are environmental contamination and intraspecific competition.

Analysis of tissues from stranded Belugas has shown high levels of environmental contaminants. An adult female white whale examined in 1979 contained 36.9 ppm mercury in the liver, and 34.0 ppm DDT

and 171 ppm PCB's in the blubber (Sergeant 1980), while a Beluga calf examined in 1972, contained 827 ppm DDT and 800 ppm PCB's in the blubber. While effects of these substances on whales are not presently understood, lower levels than those cited have been associated with premature births and reproductive failure in California Sea Lions (*Zalophus californianus*) and Baltic seals (DeLong et al. 1973; Jensen et al. 1969). It is conceivable then that these very high levels of organochlorine residues in St. Lawrence Belugas could be affecting herd production either through loss of fetuses or weakened young.

Current studies in program progress indicate that the greatest losses to the population appear to be occurring in juveniles at the time of weaning. It is not known why this seems to be happening, but it is theorized by D. Gaskin (personal communication) that intraspecific competition could be a serious problem. He reasons that if the St. Lawrence Belugas have not been able to alter their birth rate in response to overexploitation or loss of habitat, then in the present situation where habitat is being reduced, more whales could conceivably be using each habitat area. It is felt that the brunt of this situation would be born by weaned juveniles which would come into direct competition with adults for available resources. Not being experienced competitors, they would probably be the first to suffer.

Intraspecific competition could also become a problem if white whale food sources were to become significantly reduced. Growing emphasis is being placed on the harvesting of Capelin, Herring, Mackerel and Smelt in the St. Lawrence Estuary. Valdykov (1944) reports that the St. Lawrence Belugas feed on most of these species. Should stock sizes not be adequately assessed, or allowances made for poor production years and the energy requirements of other species, commercial fishing could become a future limiting factor on the population.

Established natural competitors of Beluga in the estuary are Minke and Fin whales (*Balaenoptera physalus*). Their numbers appear to be increasing in recent years along with the occasional forays of schools of White-Sided Dolphins (*Lagenorhynchus acutus*) and Harbour Porpoise (*Phocoena phocoena*), all of which are known to prey on Capelin, Herring and Smelt. The effect of these competitors on Belugas is unknown. But if more whales are becoming established in the estuary then it is possible they may exert food and space pressure on Belugas. Normally such a factor would not be considered significant; however, in view of the low numbers in the population, otherwise minor factors can prove to be important.

Potential natural predators of white whales, such as White Sharks (*Carcharadon carcharias*), and natural conditions, such as storms, rough seas and extensive ice coverage, may cause occasional death to Belugas, but are considered normal limitations on the population and not significant limiting factors.

Special Significance of the Species

Unearthed bones and skeletons of Belugas reveal this species has dwelt in the St. Lawrence River since prehistoric times. How long the population has been isolated from northern stocks no one knows, but because of this isolation the St. Lawrence white whales could now comprise a separate gene pool. The population has uniqueness in being the most southern concentration of Belugas in the world and by virtue of its location it is probably also the most accessible for public viewing and research.

As the first Canadian Beluga stock to be stressed by human development activities, this population's biological and behavioural response to human encroachment has considerable importance for resource managers since it provides indications of how Arctic populations could be expected to react to northern development projects.

Historically, the Beluga played an important role in the settlement of the St. Lawrence region. The white whale fishery of the 1800's produced numerous products that were sold widely in foreign and domestic markets. This historic value, combined with both a growing whale-tour business boosting recognition of the Beluga's tourism value and the white whales' longstanding familiarity to Quebec's coastal residents, has kindled public interest in the population's preservation.

Although the number of Belugas in the St. Lawrence River is now precariously low, the species is still abundant throughout the Canadian Arctic. However, all individual populations are much less secure than previously. The Cumberland Sound, Eastern Hudson Bay and Ungava Bay populations have declined appreciably due to over-hunting. The Beaufort Sea and Lancaster Sound populations will be exposed to the exploration for oil and natural gas thus, raising the risks associated with Arctic hydrocarbon developments. Eastern Hudson Bay Belugas are imminently threatened with loss of critical habitat at the mouths of various northern Quebec rivers because these river outflows are being altered with the construction and operation of hydro-electric dams.

Evaluation

Given the severity of the St. Lawrence Beluga population's decline, this stock is now seen as being endangered. Their diminution is suspected to be connected with past over-exploitation, recent and current reduction and alteration of essential and seasonal habitats,

population disturbance, and possible environmental contamination or intraspecific competition leading to the loss of young.

The Belugas of the St. Lawrence River have been under the protection of the Beluga Protection Regulations of the Fisheries Act since March 1979. This Act outlaws all forms of hunting, killing, chasing or wilful disturbance of these whales. Currently, measures are being undertaken by the Federal Government and the Province of Quebec to protect areas of critical habitat and lessen the disturbance caused by pleasure craft. Several research programs are also being undertaken to gain more insight into the biology, behaviour and ecology of these whales, in order to provide the proper management necessary for the survival and recovery of this population.

Acknowledgments

I would like to thank Jean Boulva (Fisheries and Oceans), André Bourget (Canadian Wildlife Service), and Richard Sears (Mingan Island Cetacean Study), for allowing me the use of reports of recent winter sightings of white whales. Thanks are also due to D. Gaskin of the Department of Zoology, University of Guelph, R. G. Greendale and P. Montreuil, Fisheries Officers of the Department of Fisheries and Oceans, R. Sears, private consultant, Quebec City; and H. Smyth of the faculty of Science, Laval University for the helpful comments and personal communications.

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Book Reviews

ZOOLOGY

The Archeology of Beekeeping

By Eva Crane. 1983. Cornell University Press, Ithaca. 360 pp., illus. U.S. $35.

Anecdotal and didactic books about beekeeping abound. With such current cute titles as "Me and the Bee" and "The Queen and I", who would have thought that anything new could be written for the layman. Yet Eva Crane has attempted this by exploring the history of man's association with bees over 8000 years.

For more than 30 years, Dr. Eva Crane has been Director of the prestigious International Bee Research Association. I once spent a rather intense day with her in the context of Commonwealth support for her Institute, and came away with impressions of a passionately devoted and articulate lady, as well as a gracious hostess. But that meeting did not prepare me for the revelation of her awesome erudition about ancient and classical history, writings, art, and artifacts, tossed out casually in the context of this book.

My difficulty with the book stems from the author's explicit intention to interest the general reader, and her implicit need to record the scholarly detail of her research. This is a tricky tightrope to walk, and when she falls, she falls heavily on the scholarly side. Mercifully, she uses the device of appendices to spare the general reader: of the 360 pages, 113 are devoted to meticulous detail of her findings and sources. Another notably successful device is her lavish use of illustrations. One could easily follow the main sweep of her thesis simply by perusing the illustrations and their captions. And if I had been tempted to skip some tedious details about the construction and dimensions of ancient bee hives I might have missed such gems as the quotation from a medieval liturgical scroll which speaks of the bees "who produce posterity, rejoice in offspring, yet retain their virginity". Good bee biology and good Christian doctrine **circa** 1000 AD!

The time span of the book extends from cave drawings of bee hunters dating from 8000 years ago, up to the invention of the modern movable-frame hive in 1851. The geographic span garners evidence from Europe, Africa, India, China, the Americas, and Australia.

This is satisfying archeology because the discoveries of ancient forms of bee hives are corroborated by counterparts in use in underdeveloped parts of the present world; they come alive with the convincing evidence that their current use differs little from how they were used by ancient hands. And probing deeper into the past is the evidence for honey *hunting* by very early people, again enlightened by vivid accounts of strikingly similar methods used by current isolated peoples. This interplay between archeological and anthropological evidence brings an unusual sense of intimacy with remote peoples and practices.

The book begins with an account of honey or bee hunting, dated by cave drawings to 8000 years ago and extended speculatively to the end of the last Ice Age. The transition from bee *hunting* to bee *keeping* was coincident with the beginnings of agriculture, particularly in the valley of the Nile. Here, the archeological record begins. It comprises detailed drawings on tomb and temple walls, and the remains of ancient bee hives. These hives were tubular pipes made of baked and unbaked clay and oriented horizontally in stacks. These horizontal hives became the standard model in the classical times of Greece and Rome, and in Asia and Africa, and are still used today.

The transition from *horizontal* hives to the *vertical* hives now universal in the western world is explored in a charming chapter on Tree Beekeeping. This is the practice of keeping and managing bees in cavities in living trees, developed uniquely in Northern Europe and dated to 2000 years ago. Suitable trees were owned, marked, recognized in laws, and assessed for taxes. What more natural than eventually to move the upright hollowed part of the tree (or some facsimile) to the ground. The dichotomy between the horizontal hives of the tropics, and the development of vertical hives in temperate climes is plausibly explained on the basis of the effects of latitude on honeybees.

The *skep*, the conical hive made of coiled straw or wicker, was the common hive in Northern Europe from the Middle Ages onwards. To protect the perishable skeps from weather, various stone shelters were built, and these constitute the archeological record of skep beekeeping. The most common shelter was the bee *bole* — a recess in a stone wall, shaped to accommodate a single skep; more elaborate *alcoves* were built into walls to shelter a number of skeps; and finally, separate bee *houses*. The richest concentration of these shelters is in Britain and Ireland, and many of the findings are recent and researched by the author.

The penultimate chapter tells the story of the achievement of the long-perceived need for a hive with removable combs, and reveals that the necessary principle of the "bee space" was enunciated 60 years before Langstroth put it to practical use in 1851. The final chapter is a delightful account of how bees, hives, and

beeswax have been represented and used in beautiful art objects from the Pharaohs to the present.

This is a book for amateur and professional archeologists, for beekeepers interested in the origins of their craft, and — yes — for the literate layman with catholic curiosity.

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Les oiseaux de St-Pierre et Miquelon

Par Roger Etcheberry (collaboration de Michel Borotra). 1982. C.P. 328, Saint-Pierre, R. Etcheberry, 78 pp., illus. $3.

Saint-Pierre et Miquelon, un département français en territoire d'Amérique, est une région dont les oiseaux ont été particulièrement délaissés par les ornithologues nord-américains. L'ouvrage dont il est question est essentiellement une liste annotée des espèces présentes aux îles St-Pierre et Miquelon avec mise à jour de documents antérieurs de d'autres auteurs. La liste ajoute 62 espèces à l'avifaune locale et porte ainsi à 248 le nombre total d'espèces rapportées pour cette région. L'avifaune est constamment mise en parallèle avec celle de Terre-neuve qui compte 310 espèces malgré un territoire beaucoup plus vaste. On remarque que des facteurs reliés à la sociologie humaine est en partie responsable du peu de connaissance des oiseaux de ces îles. Ce département français n'étant pas soumis au traité Canada-États-Unis concernant les oiseaux migrateurs, plusieurs mentions sont encore le fruit d'une chasse peu contrôlée, avec braconnage. Ceci semble également affecter la survie ou le potentiel reproducteur de plusieurs espèces dans certains habitats qui sumissent de plus en plus de dérangement. L'augmentation du nombre d'espèces est attribué surtout à une augmentation de la fréquence des observations et de l'intensité de l'espace et des périodes de temps couvertes, plutôt qu'à des extensions d'aire.

L'auteur utilise une échelle qualitative pour exprimer l'abondance relative des espèces, mais il ne précise pas comment est établi son référentiel (commun, rare, accidentel, etc). Il est intéressant de prendre connaissance des appellations des oiseaux par les habitants de l'île; certaines sont des additions à la liste des noms vernaculaires donnée par R. Cayouette et J. L. Grondin (1977. Les Oiseaux du Québec, S.Z.Q., Québec); par exemple, *Bacayère* pour le Huart à collier, *Bélarge* pour la Macreuse à ailes blanches, *Dadin* pour le Grand Puffin, *Calculot* pour le Macareux moine.

La présentation aurait pu être plus soignée, car on trouve plusieurs fautes de frappe, des citations sans référence à l'année pour un auteur dont plusieurs travaux sont répertoriés en bibliographie, l'année de publication de l'ouvrage n'apparaît qu'à la fin des remerciements (p. 69), certaines formulations francaises sont peu élégantes (p. 55, ligne 8) et la recherche bibliographique semble déficiente (on aurait dû retrouver une référence comme R. W. Tufts (1973. Birds of Nova Scotia. Nova Scotia Museum, Halifax) lorsqu'on fait état du statut de certaines espèces pour cette région).

Quoiqu'il en soit, le peu d'informations disponibles pour cette région justifie la publication de ces nouvelles données. L'auteur lance enfin un appel pressant concernant l'adoption d'une réglementation qui pourrait assurer la survie des espèces sur l'île qui est soumise à la pollution, la dégradation du milieu, le pétrole (tout le territoire est entouré d'eau), la chasse non contrôlée. Il est malgré tout encourageant de constater que de plus en plus de personnes rapportent les espèces qu'elles voient, ce qui ne peut qu'améliorer le niveau de conscience face à l'environnement.

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A Field Guide to Birds of the USSR

By V. E. Flint, R. L. Boehme, Y. V. Kostin, and A. A. Kuznetsov. Translated from the Russian by Natalia Bourso-Leland. 1984. Princeton University Press. Princeton. xxxi + 353 pp. illus. U.S.$65.

This handsomely produced, well illustrated volume on the birds of the Soviet Union is much more than a field guide. Indeed, it is a useful handbook describing 728 species of birds. There are over 300 distributional maps, 48 colour plates, and 71 charming black-and-white line drawings. The book, originally written for a series on the flora and fauna of the USSR, was first published in 1968. It was so successful that it was soon out of print.

For this English edition information has been updated by the senior author, and various useful sections were added by the translator. These include, "Notes on Birding in the USSR for Travellers," a "General Overview of Natural History in the USSR," a section on "Basic Bird Complexes [biotic zones]," and "The Five Most Interesting Birding Regions of the USSR."

The main part of the Field Guide consists of species accounts. These include field marks, habits, range and distribution, and similar species. The English name of the bird is printed in bold face type. The scientific names and Russian name appear underneath. The plate number for the colour illustration, and the appropriate distributional map number are also given before the text of the species account. The accounts are concise, interesting, and useful.

The colour plates are very well done, with clever use of space on each plate, achieved by positioning the depicted birds at such angles that, while up to 20 species may appear on a plate (the usual number is 12-15), overcrowding is avoided. Birds are numbered consecutively on each plate; there is a scale in centimeters for each plate, and the name of the bird and the page number of the relevant text are also indicated.

The line illustrations, dispersed throughout the text, show not only birds in flight, and the downy young of some species, but also nests, bill and feet shapes, bird crest and tail types. One unusual feature is a series of drawings of different birdbands issued by European and Asian ornithological associations and bird stations.

The last part of the Field Guide contains an alphabetical index of English names, a numbered cross-reference list (consisting of scientific name, English name, plate and range map numbers) followed by an index of Russian names. The cross-reference index was prepared by Peter Alden of the Massachusetts Audubon Society.

There is only one thing I can find fault with — no mention is made of the artist-illustrator whose work enhances the usefulness and attractiveness of this volume. This should be corrected in future editions.

I wholeheartedly recommend this book to any naturalist planning to visit the Soviet Union. While its price may seem steep, anyone willing to spend money on such a trip will find it worthwhile to purchase this field guide. Hopefully, university and community libraries will also acquire copies. What a pity that ornithologists attending the 1982 International Ornithological Congress in Moscow did not have the benefit of this excellent volume.

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Redwings

By Robert W. Nero. 1984. Smithsonian Institution Press, Washington. 160 pp., illus. Cloth. U.S.$22.50; paper U.S. $10.95.

The Redwinged Blackbird is one of North America's most common and familiar birds and so it is surprising that, before now, we have not had a popularized book produced on this species. Some readers may not have expected this author to be the one to finally provide us with such a volume. Bob Nero is perhaps best known for his work on Great Gray Owls (see *Canadian Field-Naturalist* 95: 378-479 [1982] for a review of his book, *The Great Gray Owl*), but he is also a prolific author on many other ornithological topics. Actually, Nero's postgraduate ornithological training involved detailed studies of Redwings in Wisconsin in the early 1950's and it is those experiences that form the core of the text.

The book is presented in a straight forward manner. It begins with an excellent gallery of colour photographs that illustrates major characteristics of the species' life history. The introduction that follows describes Nero's academic (and subsequent) involvement with Redwings. We are then provided with a broad discussion of the blackbird family (Icteridae) and a description of Nero's Wingra Marsh study area. This is followed by several chapters on behaviour (territor-

iality, courtship, mating, nesting, etc.). Descriptions of experimentally-induced changes in the normal behaviour of the Wingra Marsh Redwings, discussions of the relationships between adults and young, and a review of the management implications of the massive annual migration and winter roosts of the Redwing, complete the main body of the text. A bibliography of cited literature and a detailed index conclude the volume. These are comprehensive and well referenced.

Redwings is copiously illustrated with superb pen and ink sketches by James Carson, and with the numerous black-and-white photographs from the author and other photographers. The book is very well put together. The paper is of excellent quality and the type is clear and easy to read. The illustrations are, for the most part, reproduced in a crisp and clear fashion and there appear to be very few typographical errors in the text.

Nero obviously knows his subject and communicates the important and useful information to the reader in a clear and expert manner. Still, it does seem to drag a bit; the "sparkle" that was evident in Nero's Great Gray Owl book seems largely to be missing here. Perhaps we lose a sense of immediacy because so much of what is being described occurred 30 or more years ago. The design and layout of the book seem rather "50's-ish", thus accentuating this feeling of datedness. This is particularly evident on the title page and dust jacket.

This is not to say that Nero's delightful habit of including chatty anecdotes to clarify technical issues is missing (see page 98 for a quip by Konrad Lorenz on "wife-swapping"!). Perhaps because his studies at Wingra Marsh were formalized and academic, the predominately serious and sober tone of the text was inevitable. I personally found the text most enjoyable when Nero was describing, in his easy, comfortable way, the feeling of an early-morning Redwing marsh or his impressions of late-fall lakeshores. He has a real talent for communicating the essense of such experiences.

This is, when all is said and done, a good book. It covers its subject matter authoritatively and concisely and will be an excellent addition to the North American bird literature. If I gripe a little about the tone of the book, it is only because we were so spoiled by Nero's previous similar effort. With a wealth of information, excellent illustrations and superior production quality, *Redwings* is also a good value for its very reasonable price.

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Owls of Europe

By Heimo Mikkola. 1983. Buteo Books, Vermillion. 397 pp., illus. U.S.$40.

Did you know that a Tawny Owl has a better memory than a dog? Do you know how to make a nest box for an owl? How to attract a Long-eared Owl with a "coke" bottle? How Snowy Owls prevent cannibalism amongst their young? All of these questions — and so many more — are answered in this wonderful book.

The author is a Finnish ornithologist who is well-known to readers of owl literature (especially that of Great Gray Owls) on both sides of the Atlantic. Still, one might expect that even so prolific and insightful an author as he would be overwhelmed by the sheer volume of data which must be accommodated in so ambitious a study as this. Well, he clearly *isn't*!

Mikkola treats 17 species, seven of which (Barn, Snowy, Hawk, Great Gray, Long-eared, Short-eared and Tengmalm's (Boreal) Owl) also occur in Canada. The first part of the book deals concisely and expertly with general aspects of owl biology — general anatomy, taxonomy, hearing and vision, etc. — and includes the most detailed and complete discussion on the role and significance of owl pellets that I have seen. The second part of the book treats each species in a separate chapter, beginning with a detailed technical description of the bird and followed by a marvelously lucid description of the owl in the field, and detailed discussions of behaviour, food, breeding biology, and distribution. These treatments are all carefully crafted, copiously referenced and include references to Mikkola's extensive personal experience wherever possible. He utilizes a great deal of Scandinavian literature that otherwise would be largely unavailable to an English-speaking readership. The text is written in so flowing and economical a manner that it is difficult to appreciate that the author's mother tongue is not English.

Each chapter is lavishly illustrated with the outstanding pen and ink sketches of Britisher Ian Willis. They offer many new and beautifully-wrought perspectives on supposedly familiar — and not so familiar — situations and species. While the sketches serve to illustrate key points in the text, and do so superbly,

they also help the reader to "settle into" the landscape and environment of the particular species at hand. The depiction of a desert mirage (page 255) in the African Marsh Owl chapter and that of a Short-eared Owl soaring along a heath ridge (page 233), for example, greatly aid in placing the species in context for the reader. Willis has also provided eight pages of magnificent colour sketches which illustrate each species and their major European subspecies. He employs over 60 individual illustrations here to show each species in sitting and — very importantly for the birder — in flying positions. The *Strix* owls (Great Gray, Ural, etc.) are somewhat too lightly coloured in my copy but this may be a production error. Otherwise, these are outstanding visuals — especially those for Snowy, Boreal, and Short-eared Owls.

In addition to Willis' terrific work there is a 32-page section of black-and-white photographs that illustrates each species, as well as views of their nests, pellets, hunting behaviour, etc. in many cases. They are technically excellent photos (with the exception of a few of rare species such as the Brown Fish Owl and Hume's Owl for which the choice of material is obviously more restricted). Detailed European range maps for each species and more generalized world range maps (which are quite reasonable for Canadian species), as well as numerous graphs and tables, provide the remainder of the illustrative material.

Mikkola completes the main body of his text with a section discussing the ecological relationships of European Owls (in which he identifies many questions for further research) and chronicles the checkered record of protection afforded these animals. This latter discussion includes a detailed country-by-country statement of owl protection legislation (or the lack thereof). This is followed by an exceptionally full list of references that includes virtually all of the most important (as well as much of the obscure) Canadian literature in its over *800* citations. Almost 40 pages of tables (which provide back-up to many of the statistical analyses in the text) separate the literature citations from a very complete and useful index.

The volume is well produced, solidly bound, and with good quality paper. The slightly ornate type style and closely-set characters (resulting in more letters/line than might be expected) detract from the ease of reading, however. Reproduction of the illustrations is good.

It's very difficult to fault the text on any score. Mikkola's description of peak activity periods at other than nesting time (*viz*, the degree of diurnal *vs* nocturnal activity) is somewhat vague for some species and he seems to evade the question of the frequency and significance of food storage by owls. Still, these are minor problems.

Mikkola's concern for the protection of owl species in Europe, his distaste for the needless destruction of so many of them, and his admiration and affection for these creatures, are clearly evident. He sums up his purpose in writing the book most aptly with the statement ". . . this book seeks to win new friends for owls . . .". That, it most certainly does!

Mikkola and Willis have created a beautiful, authoritative and captivating book that ranks with the best of the world's owl literature. It will be a standard reference for many years to come and I recommend it wholeheartedly.

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Behavioural Ecology: An Evolutionary Approach

Edited by J.R. Krebs and N.B. Davies. 1984. Second edition. Sinauer Associates, Sunderland, Massachusetts. 493 pp. illus. Cloth U.S.$42; paper U.S.$25.

The first edition of this work was widely acclaimed as a valuable contribution in its area, and the second continues this success. In the tradition of subsequent editions, it is "bigger and better", with fewer but larger text pages. The near doubling of the bibliography reflects the huge amount of research which has been reported in the intervening half-dozen years. Intended as an upper level text, the book consists of 15 chapters by leading investigators in Britain and North America. The material is grouped into four sections which are each briefly introduced. In the first section, on methods and ideas, Clutton-Brock and Harvey provide a good discussion of comparative approaches in investigating adaptation and associated problems. In a thorough review of Maynard Smith's concept of evolutionarily stable strategy, Parker appropriately evaluates it as "the most important recent development in evolutionary theory". Grafen critically considers types of selection proposed to be acting on animals.

In the first three chapters of the second section, on predators and prey, the optimization approach is front and centre stage. The approach views biological features as optimized outcomes of selective forces. An excellent chapter by Krebs and McCleery introduces

models and problems associated with the approach, which is then used in analyses of animal groups and territories by Pulliam and Caraco, and Davies and Houston, respectively. The inclusion of a fourth chapter, on learning (including constraints on learning and species-specific adaptations) by Shettleworth, is a definite improvement to this edition: despite the difficulty of observing learning in the field, the increased attention being paid to proximate mechanisms by functionally oriented biologists in an indication of a healthy interest for more comprehensive understanding in behavioural ecology.

The four chapters of the third section, on sex, mating systems, and life histories, squarely confront the great complexities of these topics. They highlight many outstanding issues, such as that of the heritable genetic variation underlying sexually selected characters. Maynard Smith tackles the general problem of the ecology of sex, such as the evolution of sex ratios, while Partridge and Halliday consider mating patterns and mate choice. Vehrencamp and Bradbury review the ecology of mating systems, especially the difficulties of measuring fitness. In Horn and Rubenstein's chapter on behavioural adaptations and life history patterns, the intricacies of concepts such as r-and K-selection, and reproductive value are usefully scrutinized.

The final section deals with cooperation and conflict. Fine chapters on cooperative breeding, by Emlen, and social behaviour of insects, by Brockmann, examine the underlying genetics and evolutionary processes. A stimulating presentation by Krebs and Dawkins on the arms races, between manipulating actors and mind-reading reactors in animal signaling concludes the text. Throughout, the book is well composed and illustrated (ignoring "behaviours" and "satelliting"!).

The operative intellectual viewpoint is firmly entrenched within the adaptationist framework, that dominant position that functional phenomena in biology are indeed adaptations. The consequent themes of optimization and evolutionarily stable strategies reverberate throughout the text, and little attention is paid to criticisms of them (although one pair of authors reflects on the possibility that a potential, ambitious analytical program which they outline is only mental masturbation). Quantitative techniques, and the need for both theoretical refinements and experimental tests, also receive clear and considered prominence. Taxonomically, coverage reflects the emphasis in research on birds, mammals, and social insects; the chapter by Charnov on the behavioural ecology of plants, as the editors take pains to point out, does indeed illustrate the breadth of many ecological and evolutionary concepts, but it is for other fundamental reasons (such as the lack of a nervous system) that plants have not been included in behavioural volumes for half a century. Perhaps most importantly for the growth of behavioural ecology over the long term, at several places in the book the continuing confluence of historically separate areas, such as psychology and ecology, or the study of life histories and of social behaviour, reveals exciting synthetic developments. In sum, this is a superb volume.

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Flyways: Pioneering Waterfowl Management in North America

Edited by A. S. Hawkins, R. C. Hanson, H. K. Nelson, and H. M. Reeves. 1984. Superintendent of Documents, U.S. Government Printing Office, Washington. xix + 517 pp., illus. U.S.$17.

In the 1930s, because of severe drought and continuing wetland drainage, the future for waterfowl looked bleak indeed. A small cadre of Americans and Canadians, recognizing that most ducks and geese were raised in Canada, developed a waterfowl management system based on four major "flyways." This book tells their story.

Four waterfowl biologists (Hawkins, Hanson and Reeves are retired while Nelson is still active) have performed a valuable service in collecting and editing, before it is too late, reminiscences from 53 of their fellows. These accounts, although occasionally rambling and sometimes repetitive, contain a great deal of human interest and adventure. Lightly edited, to allow the style and personality of each contributor to "shine through," they have been organized into a coherent whole. One senses obvious nostalgia for the "good old days" before the field worker was engulfed by bureaucracy, and when many worked from dawn to dusk for seven days a week. These men, at the interface between theory and practice, between biology on the one hand and the new profession of game management on the other, improvised many new techniques.

The first six narratives tell what it was like in the 1930's to be a duck hunter, a game warden, a field

biologist, a pilot, a teacher, and a surveyor. These are followed by biographies of giants in the field who are now dead. The Americans include Clarence C. Cottam, Jay N. Darling, Ira N. Gabrielson, Charles E. Gillham, Edward Goldman, Luther J. Goldman, Edward R. Kalmbach, Aldo Leopold, Frederick C. Lincoln, Waldo L. McAtee, Edward A. Preble, J. Clark Salyer, and Alexander Wetmore. The Canadians include the equally illustrious Hoyes Lloyd, and Canada's first federal migratory bird officers, Harrison F. Lewis, James A. Munro, J. Dewey Soper, and Robie W. Tufts.

Canadians contributing reminiscences are F. Graham Cooch, William G. Leitch, Gerald W. Malaher, Ernest L. Paynter, and Peter Ward, while Americans who tell of their experiences in Canada include C. Edward Addy, Charles H. Bell, Arthur R. Brazda, Walter J. Breckenridge, Leon D. Cool, Charles D. Evans, Fred A. Glover, Rossalius C. Hanson, William H. Kiel, Jr., John J. Lynch, Harold S. Peters, Henry M. Reeves, Allen G. Smith, Robert H. Smith, David L. Spencer, and Jerome H. Stoudt. All in all, these names form a "Who's Who" in waterfowl management. I found their chronicles of particular interest because I had met a few of them and had read about most of them, while a student banding ducks for Ducks Unlimited in the 1940s.

Flyways tells of investigations in such areas as waterfowl food habits, migration, nesting success, predation by crows and raccoons, botulism, and lead poisoning. The development of techniques such as aerial and ground population surveys, use of wing samples to determine species composition in the hunter's bag, and duck banding, including J. B. Gollop's use of soft-mouthed dogs to catch young mallards, are recounted. The subsistence hunting needs of northern native peoples, the search for Whooping Crane nesting grounds, the development of appropriate game regulations, attempts at marsh habitat preservation and restoration, and the important matter of waterfowl damage to farm crops, are all recounted.

Well-illustrated with numerous photographs of people, localities and events, three helpful maps, and Al Hochbaum's superb sketches, this is an attractive book. Although marred by occasional lapses in typesetting, and inconsistencies in presentation of biographical data, a bothersome lack of documentation and of a bibliography, this book nevertheless is fun to read and a valuable source of historical material. The Canadian scene has been covered adequately, though Bednarik's chapter on the resurgence of the Canada Goose numbers should have mentioned the results achieved by Fred G. Bard at Regina, Saskatchewan.

I will refrain from the temptation to select examples of the most important, most interesting or funniest anecdotes, but will conclude with Carl R. Madsen's statement that wetlands are ". . . for ducks *and* people. Prairie wetlands are not only the backbone of this continent's duck production; they also provide habitat for resident wildlife and nongame species, while holding special values for people: runoff water retention, water storage and aquifer recharge, nutrient uptake and recycling, stream flow regulation, lake stabilization, and fish production. All of these values contribute to the recreational and economic well-being of those who live near wetlands. In many areas of the prairie pothole country, recreational values derived from wetlands are marketed at resorts, shopping centres, main streets, and service stations. The natural resources on which these industries depend are inseparably entwined with our agricultural enterprise and other business pursuits.

We seem to have a desire to live, work, and play in places that offer variety. Wetlands are one of the major contributors of diversity to the prairies, a region of rich agricultural productivity."

The price, even for a government publication, is an incredible bargain.

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Bird Migration: The Solution of a Mystery?

By R. Robin Baker. 1984. Holmes and Meier, New York. x + 256 pp., illus. Cloth U.S.$32.50; paper U.S.$24.50.

Few topics in ornithology and behavioural biology have attracted such attention or led to the production of such diverse data, conclusions, and controversies, as how birds find their way. One especially memorable paper of half a dozen years ago, reporting collaborative research between Americans and Italians intended to resolve conflicting findings, contains separate Discussion sections by the two still-arguing groups! (As a neophyte graduate student, I chose bird navigation as an essay topic, only to discover that the second edition of G. V. T. Matthews' text was soon to be published, too late for my perusal but in time for my professor to compare with my essay. I had not yet learned that, like everyone else, scientists rarely change their views on matters after puberty). Baker has written extensively on animal migrations, and this

most recent book has been prepared as an update for a broad audience. The opening three chapters provide a historical introduction to the field and establish terminology (such as "navigation" versus "piloting") and methodology, including experimental designs and statistical tools. Two chapters then consider how birds could navigate and the sensory cues that could be used. The various compasses available to birds (sun, polarized light, moon, stars, magnetic fields) and their hierarchical relations, modes of operation, and ontogeny are discussed in the next four chapters. The final chapters deal with the possibility of grid maps and with the details of short- and long-distance navigation. Baker decides that grid maps have yet to be shown convincingly, and that local landscape maps and compasses are sufficient mechanisms to account for observed behaviour. Thus he concludes that the mystery of bird migration will probably eventually be seen as having died a quiet death as a result of research over the past decade, and approvingly cites the suggestion that it was originally fabricated by researchers as a strategy to obtain research funds. The book is well indexed and referenced, and generously illustrated, although the figures and text are not always fully interwoven.

This work provides a comprehensive treatment of what is known about bird migration. A solid, critical evaluation of the often conflicting data is presented in a smooth and flowing style. For instance, Baker raises the interesting point that surgery on the olfactory system may disrupt a magnetic sense. The breadth of the research reported, from its original core in behaviour and ecology to more recent investigations of sensory, genetic, and developmental problems, indicates the maturation of the field. Although the topic is avian navigation, the author cannot resist including some of his comparative research on humans. Naturalists will rejoice that magnetoreception is impaired by wearing polyester clothing as opposed to cotton clothing or nothing at all. Still on humans, Baker surely errs in lumping North American cotton pickers with Lapplanders and Bedouins as long distance seasonal migrants. Given the intended general readership, it is surprising that nanoTesla, the unit for measuring the density of magnetic fields, is introduced on p. 50 (as nT) but not written out until p. 113. In sum, for those interested in how birds know where they are going, this is a good book.

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Birding with a Purpose: Of Raptors, Gabboons, and Other Creatures

By Frances Hamerstrom. 1984. Iowa State University Press, Ames. 130 pp., illus. U.S.$13.95.

Anyone attempting to identify a 'Gabboon' in an up-to-date bird book would be doomed to disappointment. The term, coined by Dr. Frances (Fran) Hamerstrom, the first woman graduate in Wildlife Management in the United States in the 1930s, does not refer to a bird. Nor is a gabboon the "lowest form of life" as some mischievous characters in *Birding with a Purpose* put it. Instead, it is a keen, unpaid helper who bands birds — a true birder with a purpose.

Over the years the Hamerstroms engaged hundreds of gabboons to help with their studies of prairie chickens, and birds of prey in Wisconsin. Many of their adventures were chronicled in Fran's previous book, the delightful *Strictly for the Chickens*. In this new work, which is dedicated to the gabboons, "those rugged, persistent individuals . . . who, without pay, band birds to enhance our understanding and further conservation of wildlife," the author recounts further adventures. Northern Hawk-Owls, Snowy Owls, Great Gray Owls, Bald Eagles, and Harris' Hawks share the limelight with 'bal-chatri' traps (for catching birds), tethered pigeons, Harriet the half-grown rat, and an 'electric mouse.' Among the human protagonists we find the Hamerstrom family, husband Frederick, and children Elva and Allan, and friends and raptor experts Dan Berger and Nancy and Helmut Mueller. There is also the unruly, but truly enthusiastic group of young birders euphemistically called 'The Rockford Bunch,' a "treasured, but sometimes demanding" part of Fran's existence. The outcome is a series of amusing, but instructive vignettes of bird-banding adventures, including some encounters with farmers, employees of a powerhouse, sheriffs, and policemen. When one of the latter wished to become a gabboon, Fran, after a period of probation — made him one.

It would be unfair to divulge more. The book should appeal to naturalists of all ages. Some may even be lucky to become gabboons.

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Nature's Night Life

By Robert Burton. 1982. Blandford Press (Canadian distributor Oak Tree Press, Toronto). 160 pp., illus. $22.95.

". . . Animals have several options for organizing their activities. Nocturnal activity is just one possibility which has its peculiar advantages and disadvantages, and requires certain adaptations in the structure of the animal to become practicable." That is an admirably clear statement of an important concept, for any audience. It sets the tone for this survey of nocturnal animals (no sleeping leaves or night-scented orchids) from many parts of the world.

Not all of the book is as good as that first quotation suggests. Much effort is spent addressing an ill-posed question, namely what single, obvious factor accounts for this animal being nocturnal? The pages of just-so stories given in response are interesting but unsatisfying, because "there are so few instances where it is possible to point to a clearcut reason for nocturnal behaviour or to clinch an argument with observations or experiments which demonstrate the advantage accruing to the animal. All too often, there are exceptions. . . ." The author says this often and eloquently, but does not desist from looking for the quick fix. In the end, though, his willingness to be critical of his own ideas, as well as those of others, is appealing, and makes up for his occasional overenthusiasm in milking meagre data.

A similar freshness of outlook is apparent in other matters as well. For example, he has a section on the plains of East Africa. Signs of death are everywhere obvious on these plains at night, from the roar of the lions to the spider webs that carpet the ground. It is not a Disney paradise. The author treats this system with the touch of respect it deserves, without being stuffy about it. On the other hand, I think it is a bit much for him to speak only of "the Africa of tourists and scientists" — there are a few other people involved.

There are many nice pictures, a good range of examples from invertebrates and vertebrates, and a reasonable underpinning of biological theory. It is quite a good example of how to popularize science.

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Caribbean Fish Life: Index to the local and scientific names of the marine fishes and fishlike invertebrates of the Caribbean area (tropical western central Atlantic Ocean)

By Jacques S. Zaneveld. 1983. E. J. Brill/Dr. W. Backhuys, Leiden, Netherlands. xviii + 163 pp., 1 map. D.Gld.56.

This small paper-backed publication lists vernacular and scientific names for common marine fishes and lancelets (hence the fishlike invertebrates in the title) for the Caribbean. About 760 species are included in 143 families. For the purposes of the book the Caribbean is defined as the Caribbean proper as well as the areas around the Bermudas, the Bahamas, and the south Atlantic coast of United States. Fishes of the Gulf of Mexico and those for which no common name has been mentioned in the literature are stated to be omitted, as are fishes seaward of the 200 metre depth line. For higher classification Leo S. Berg's 1958 classification of fishes is followed; J. S. Nelson's (1976, John Wiley & Sons, now in second edition, 1984) *Fishes of the world* would have been a better choice.

The book is divided into Introduction, References, and Additional Literature, Table 1 (abbreviations for languages), Table 2 (abbreviations for islands, countries and references), the List (comprising the body of the text), Indices to scientific names, and vernacular names. A map of the principal Caribbean islands and nations is included.

In the list at the family level and above usually only the scientific and English common names are given. Within the families the species are listed in alphabetical order by scientific name. The genus and species name is printed in boldface which makes it easier to pick out. Following the scientific species name is the name of the author, and sometimes, in parentheses, a synonym. A check of 20 scientific names against my own manuscript list of fishes of Canada showed agreement in all cases but one where Zaneveld appeared to have the more up-to-date usage. Under the scientific name are one or more letters, abbreviation for one of the seven languages covered. Following each letter is one or more vernaculars whose source is indicated by abbreviations for islands/nations and references. It is valuable to have the source documents indicated.

The accepted Engish vernacular for the American Fisheries Society list of common names generally seems to be included, but one may also find addition-

ally out-of-date or imprecise vernaculars listed, e.g. nine eyes and lamprey eel for the sea lamprey, *Petromyzon marinus*, for USA. An English vernacular is given for most species but the French vernacular names seem to be less complete. For the first 110 species in the Caribbean list I was able to add French names for 14 species which lacked them, and 9 French synonyms from my manuscript list of fishes of Canada. Of course it might be argued that these French vernaculars are not prevalent in the Caribbean, but this criticism might also be applied to some of the FAO "book" French names included. It is unfortunate that FAO translators have often overlooked the prior existence of French-Canadian vernaculars and have introduced newly coined "book" vernaculars. I am unable to comment on vernaculars from the other five languages. The last item under each species is a one sentence statement of the world range of that species.

An index to scientific names is provided. Species are indexed under genus but not under the species name. All higher level taxa are indexed. In the vernacular index *little tuna* and *tunas* are indexed, but not *tuna, little*. The inclusion of these indices makes this publication really much more worthwhile, but I am prejudiced in favour of united indices with both common and scientific names — this saves the reader from first having to find the appropriate index.

Lists of common and scientific names are useful to editors, fisheries management, ichthyologists, and translators. They are especially useful in an area, such as the Caribbean, where the fauna and linguistic heritage is rich. Zaneveld is to be complimented for accepting the difficult challenge of assembling this list, which will be valuable to all those interested in studying and managing Caribbean fishes.

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The American Darters

By Robert A. Kuehne and Roger W. Barbour. 1983. The University Press of Kentucky, Lexington. 177 pp., illus. U.S. $45.

Darters are small, often colorful, fishes of the perch family (Percidae) that live mostly on the bottoms of streams from which they dart (hence their name) to seize their minute prey. The three larger North American species of the perch family, the yellow perch, the walleye and the sauger, are well known. The (at least) 140 species of darters comprising the subfamily Etheostomatinae are poorly known to the public or even the angler or naturalist. This is a pity because many have beautiful colors, interesting courtship and parental behavior, and varied adaptations to their environment. The authors describe this as a book about darters, not a treatise on them.

The book covers all named and some un-named species of darters including those of United States, Canada (12 species), and Mexico. The book is divided into the following sections: Acknowledgements, Introduction, Glossary, Keys, and sections on the following genera and their species: *Percina, Ammocrypta* and *Etheostoma*, References and an index. Treated in this book are 31 species of *Percina* (4 Canadian), 7 of *Ammocrypta* (1), and 94 *Etheostoma* (7).

The Introduction describes the distinctions between the darters and their relatives, the layout of the book, the photographic techniques, and the laws and ethics of collecting. The three-page glossary covers anatomical, ecological and other technical terms. Branchiostegal ray is defined as gill ray; this is incorrect (gill rays are cartilaginous rods in the interbranchial septa).

The key to the species of darters occupies 14 pages and uses 68 photos (to illustrate characters). Most of the key characters are distinctive and many are illustrated. Some key couplets use only a single character.

The body of the text consists of one to three pages describing each of the genera and their subgenera, and species accounts which vary from one-half to one and one-half pages.

The species accounts have the following headings: Description, Distribution, Natural History, Abundance, and Name. The descriptions are quite detailed and describe scalation, colour, fin ray, scale and vertebral counts, and sexual dimorphism. The concise paragraph on distribution is supplemented by a small 8.5 cm standard base map of the United States, southern Canada and northern Mexico with the native range shown by shading. Notes on habitat, species associates, life history, behavior and hybridization are presented under Natural History. This will be the most readable and interesting section for the average reader, and is usually the longest section after Description. The presence of many short Natural History

accounts should spur further study. Under Abundance is an account of how common the species was and is, for those species whose range has been influenced by man. The meaning of the scientific name is explained under Name.

In the middle of the text are found 24 color plates, each with six photos of a darter. Most photos are of freshly caught specimens; photos of preserved specimens are so noted. Emphasis is placed on the more colorful breeding males, some of which are so splendid that it is a pity that some whole-page plates of single individuals were not included.

Examination of the 8½ pages of references shows that Scott and Crossman's *Freshwater fishes of Canada* was heavily relied on for Canadian information and more recent Canadian references were largely omitted. However, contrary to Scott and Crossman, *Etheostoma olmstedi* is treated as a full species rather than as a subspecies of *Etheostoma nigrum*. Kuehne and Barbour's maps do not show the occurrence of *Etheostoma exile* in southwestern Alberta, nor *Percina caprodes* in the La Grande Rivière system of Québec where it extends into the centre of the province. I did not note any Canadians in the acknowledgements.

A brief comparison with Lawrence M. Page's (1983) *Handbook of darters* (T. F. H. Publications, Neptune City, New Jersey, 271 pp.) is useful. Page devotes less space to natural history but includes spot distribution maps which are superior to Kuehne and Barbour's. Page's color photos are not as good but are more numerous and he includes some habitat photos. Page adds sections on general darter ecology, evolution, zoogeography, a list of species with state/province and a list of species by state/province, as well as brief synonymies under each species and almost twice as many references — resulting in almost 100 more pages in Page's book. Both books are well written, cover much the same material in the species accounts, and both can be recommended to the general reader; the differences noted above may guide the specialist in her/his choice or they may choose to purchase both.

The student of North American darters would do well to add *The American darters* to her/his bookshelves. The aquarist, naturalist, and angler would find much of interest in this account of the miniature aquatic peacocks inhabiting our waters.

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The Reptiles of British Columbia

By Patrick T. Gregory and R. Wayne Campbell. 1984. Handbook No. 44. British Columbia Provincial Museum, Victoria. 103 pp., illus. $3.

In the richness of its herpetofauna British Columbia is exceeded in Canada only by Ontario and Quebec. This diversity is related to the diversity of the climate which is reflected by habitats ranging from semiarid steppe to coastal rain forest. The present work replaces Handbook No. 3 by the late G. Clifford Carl and "incorporates much of the information in the earlier work and brings up to date the results of herpetological research from the past 30 years".

This book is divided into two main segments, introductory, and species accounts, the latter being the much larger and main part of the book. In addition to the introduction per se, the first section tells how the reader may learn more about British Columbia reptiles by listing pertinent publications. Following it is a discussion of systematics and the classification of reptiles as well as how to use the identification keys. The general biology of reptiles is discussed under such headings as Relationships and Diversity, Characteristics (or what makes a reptile a reptile), and Distribution. Of special interest, in regard to the Canadian fauna in general, is the section on Adaptations to Northern Environments in which a discussion of the adversity of northern environments to reptiles is followed by one of adaptations of northern reptiles (reproductive, physiological, and behavioural). The rich faunas of the tropics rapidly diminish as one proceeds toward the poles and the species which live in high latitudes are able to do so because of special adaptations. As the authors point out, this is one of the most promising areas for herpetological research.

The checklist of British Columbia reptiles includes 18 species, two, possibly three, of which (all turtles) are introduced and probably extirpated.

The species accounts are arranged in three parts: turtles (4 species); lizards (3 species); and snakes (9 species). Each of the three parts begins with a good introduction to the group in question, discussing such subjects as structure, feeding habits and habitats, reproduction, senses, importance of colour, thermoregulation, defenses, and locomotion, as well as how to find the animal. There is a key to each group of reptiles, and, for the snakes, a field key as well, which does not require actual handling of the species, for one, the Northern Pacific Rattlesnake, is dangerously venomous.

Species accounts vary in length and include such subjects as: Description; Habits and Habitat; Feeding and Growth; Reproduction; Subspecies; and Range and Distribution. As well, there is an excellent drawing of each species, rendered by Keith Taylor or Brigitta Van Der Raay, and except where only one or two specimens are known, a spot map for each species. Following the species accounts is a section on introduced and other species that may eventually be found in the province. There is a glossary, and a list of references that will lead the reader deeper into the subject of herpetology. Species are indexed by both common and scientific names.

I noticed only one error, on page 18: "page 27" should read "page 19". I would have preferred documentation in the text, especially since this work "brings up to date the results of herpetological research from the past 30 years". However, as the authors indicate, this is available in the British Columbia Provincial Museum publication "A Bibliography of Pacific Northwest Herpetology", by R. Wayne Campbell, Michael G. Shepard, Brigitta M. Van Der Raay, and Patrick T. Gregory, 1982.

This handbook is well done and I congratulate the authors and the British Columbia Provincial Museum for producing another handbook worthy of the excellent series which is their tradition. I heartily recommend this publication to anyone interested in the natural history of British Columbia or in the herpetofauna of Canada.

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Amphibians and Reptiles of Nova Scotia

By John Gilhen. 1984. The Nova Scotia Museum, Halifax. 162 pp., illus. Cloth $29.95; paper $19.95; poster $2.95.

The prime purpose of museums is to gather material (while it is still available) and preserve it and guard it in perpetuity for future generations. Hopefully, someday a specialist will study all the objects of one category and produce an informative scientific treatise. That exercise satisfies the small scientific community but a museum has a further responsibility to disseminate the scientific discoveries to the general public and to the schools in a form that is interesting, informative, and visually attractive. The Nova Scotia Museum staff and John Gilhen have accomplished that and more.

The Amphibians and Reptiles of Nova Scotia is more than a field guide and more than a summary of Gilhen's 20 years of personal herpetological investigations in Nova Scotia. He has prepared a fascinating volume that goes back 300 million years to the earliest fossil Nova Scotian amphibians and reptiles. This is followed by a discussion of the effects of the Ice Ages and the relatively recent postglacial migrations and recolonization of Nova Scotia and the resultant peculiar distribution of these species within the province. We are then introduced to Micmac prehistoric snake and turtle artifacts, the herpetological observations recorded in journals of early explorers of the 17th and settlers of the 18th century, and a survey of the naturalists of this century and their contributions. Each of these chapters is complimented by interesting photographs and maps, in fact the entire book is nicely illustrated. The photos, by Ronald Merrick, are large, often artistic, and often unusual.

With this background, Gilhen has set the stage for his thorough examination of each species of Nova Scotia salamander (4), frog (8), turtle (7), and snake (5). Here the author has included scientific data as well as much general information. After reading through this section of the book, one appreciates how successfully the author has accomplished his goal of having his source book appeal to the general public, students and teachers, naturalists and professional scientists. This unusual integrated approach introduces the non-professional to how scientific data is amassed and how it is organized and analysed. The author also points out where and why there are gaps in our knowledge, and thus hopefully provides a stimulus to a young potential herpetologist.

The faunal coverage is so thorough that a special chapter on sea serpents is included! There is a sensible discussion of problems of habitat destruction and feasibility of conservation measures, an extensive bibliography, and a useful index.

Yes, if you have been wondering, there are color illustrations of each species, but they are out of the ordinary and deserve special mention. First, the paintings were done by a mammalogist, Frederick Scott, and are superb. Second, color pattern variations within each species are depicted (5 for Spring Peeper; 3 for Green Frog; etc), a refreshing and realistic approach to the vexing problem of reducing individual variation to a typical specimen. Third, these paintings are pleasing to the eye, and the Nova Scotia Museum had the foresight to reproduce the set on a separately available

poster, suitable for classroom, office, or den.

This uncritical reviewer must admit some bias, having done his zoogeographic teething on Nova Scotia's herpetofauna, but I confidently predict that active provincial museums across Canada will begin emulating the style of this Nova Scotia Museum publication. This is not a book just for Nova Scotians, because these species range well into Ontario, have close relatives on the prairies, and even frequent the coast of British Columbia as sea turtles — a book suited to a general and professional audience coast to coast.

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An Analysis of Toads of the *Bufo americanus* Group in a Contact Zone in Central Northern North America

By Francis R. Cook. 1983. Publications in Natural Sciences No. 3, National Museum of Natural Sciences, Ottawa. viii + 89 pp., illus. Free.

Because this publication was derived from Cook's 1978 doctoral thesis, it contains numerous tables and appendices which are not the most stimulating reading. However, in addition to fine well-labelled drawings, Cook does include interesting accounts of his field work, and a reader would have little trouble following the clearly written dialogue. Publications such as Cook's are reminiscent of studies published three or four decades ago in that the study was undertaken over a long time period, involved a great number of individual samples, and required considerable patience for the meticulous detail of measuring and counting 34 different morphometric and meristic characters from more than 4000 toads. In today's scientific community the generation of short fast papers is a survival technique to avoid "perishing" at the hands of granting agencies which are more interested in titles than content. Unlike the early studies, however, Cook's analytical methodology involved computer generated univariate ratio analyses and discriminant function analyses. In addition to the morphological analyses, the study incorporates data derived from acoustics, breeding biology, experimental hybridization, and mark-recapture experiments. Few present studies, which use some of these techniques, have even a small fraction of the data base which was used by Cook. Even the computer could not handle all the information at one time. The power of discriminant function analyses is appreciated when we learn that the computer picked out one of 1644 specimens which was misclassified and this turned out to be a measurement error.

Cook provides a very clear description of the procedures involved in the different analyses and the utility of the procedures for systematics. Sections of this publication should be required reading for those students who contemplate using discriminant function analyses. The results lead into a theoretical discussion of species concepts and Cook concludes that the Canadian Toad and the American Toad are subspecies but close enough to being species that they could be considered megasubspecies. The process of speciation is an exciting area of research but controversy lies in the application of names to a dynamic process. If two or more species are derived from a single species, at what point can they be considered "good species"? Or, if two species hybridize and exchange genes, how much gene exchange would be required before we would consider the two species to have merged into a single species? Cook clearly documents morphological and acoustic differences between the Canadian Toad and the American Toad which would justify specific distinction but there is an area of contact where the morphological characters merge and intermediate individuals are common. The proposed scenario is post-pleistocene secondary contact of populations which morphologically diverged in response to different environments. The final outcome of the secondary contact will probably not be realized for another few thousand years. The application of names at the present time is subjective (and controversial). Megasubspecies is not a commonly used term and has not previously appeared in herpetological literature. It has received little use in other groups since its proposed usage in 1976.

Cook also discusses many species of toads in North America, questions the validity of *B. hemiophrys baxteri*, rejects the validity of *B. americanus copei*, and refutes the generality that *B. americanus* is larger in northern populations than it is in more southern populations. This publication will surely stimulate additional research concerning North American toads, contact zones, and the process of speciation.

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BOTANY

More Bird's Nest Fungi (A Supplement to "The Bird's Nest Fungi" — 1975).

By Harold J. Brodie. 1984. Les Éditions Lejeunia, Nouvelle Série No. 112. La Société Botanique de Liège, Sart Tilman 4000, Liège, Belgique. 70 pp., illus. 260 Belgian francs in Europe. 300 Belgian francs outside Europe.

As the subtitle indicates, this is a supplement to Dr. Brodie's 1975 world monograph on the bird's nest fungi, bringing that authoritative publication up to date.

In the taxonomic updating, four recently described species and one form are added, new distribution data are given, and two of Lloyd's poorly described species are dealt with in detail. Students will welcome, also, the keys in both French and English for the identification of the Nidulariaceae, including a modification of Dr. Brodie's 1977 key to the genus *Cyathus*.

Dealing with recent research on morphology, scanning electron microscope studies of the basidiospores and fruit body structures are summarized. There is a most intriguing section on the nature and function of antler hyphae in the genus *Nidula*, and an important section deals with recent research into the physiology and chemistry of the bird's nest fungi. Research on the use of *Cyathus stercorius* as a biodegrader of lignocellulose raises the exciting possibility of practical application in the fields of food and energy production. Chemists have now isolated more than fifty chemically interesting compounds synthesized by the bird's nest fungi, some with anti-microbial properties. In addition to possible commercial applications, Dr. Brodie forecasts that this spate of chemical analysis will prove a boon to mycologists in solving some of the taxonomic problems of this group of fungi.

Added to all this solid information, Dr. Brodie, true to form, charms his readers with several pages of delightful bird's nest anecdotes. Equally delightful, throughout the Supplement is the author's rare mastery of the English language, adding revealing glimpses of humour, modesty, and enthusiastic excitement to the bare scientific facts of the paper.

There is a short section of *errata* to be applied to the 1975 monograph, with several amended descriptions. The Supplement itself contains a number of trivial but annoying typographical errors. A bibliography of nearly fifty titles published since the 1975 monograph will be indispensable to students of the bird's nest fungi. There is a comprehensive index. The Supplement is illustrated with twenty-five photographs, seven of them SEM photos.

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ENVIRONMENT

Scientific Studies on Hudson and James Bays/ Recherches sur la baie d'Hudson et la baie James. Volumes I and II.

Edited by I. P. Martini. 1982. Selected papers presented at the James and Hudson Bay Symposium, University of Guelph, Guelph, Ontario, Canada, 28-30 April 1981. Le Naturaliste canadien 109(3-4): 300-670 + 671-1019. $28.

Canada's inland sea, formed by Hudson and James bays, has had an enormous impact on our history, climate, environment, flora, and fauna. *Le Naturaliste canadien* presents a summary of current research on this inland sea, including 60 of the 94 papers presented at the Guelph symposium. Objectives of the symposium were to report on ongoing research in the bay and its hinterlands, to foster interdisciplinary discussion and to determine the need for future research.

Papers in the symposium are grouped under geology and geomorphology (8 papers), climatology and permafrost (4), soils (5), vegetation (6), mapping and ecological land classification (5), physical oceanography (7), marine ecology (6), environmental impact of hydroelectric projects (5), wildlife biology (5), and human ecology (7), as well as an *avant propos* and an introduction. Ten of the papers are in French, the rest in English. All papers have a French and an English résumé.

I shall try to give a feeling of the variety of the papers and their essential findings by giving a succinct summary of a sample of the presentations. A paper by W. W. Shilts on the quaternary of the Hudson-James bay region suggests that as many as six major glacial advances originated in Keewatin and Quebec-Labrador, and that Hudson Bay was a zone of convergence rather than an ice sheet centre. A study of present day marsh foraminifera by D. B. Scott and

I. P. Martini suggests that former sea levels could be located to within plus or minus 10 cm by studying fossil forams.

Analysis of data from thermocouples of J. Poitevin and J. T. Gray in six deep holes demonstrated permafrost bodies up to 180 m thick near the coast but lacking at sites 125 km or more inland. The wave-washed, treeless coast with strong westerly winds is less well covered with snow and exposed to greater heat loss. C. Tarnocai shows that younger soils occur close to the coast due to glacial rebound (1.0-1.3 cm/century) and emergence of the sea floor. The pH, calcium, magnesium, sodium and ash levels decrease towards the interior.

E. Gorham summarizes major unsolved problems in peatland ecology and his paper provides several leads for possible doctoral theses. S. Cowles showed that the net effects of lichen mats are beneficial on growth of black spruce.

S. Pala and W. Weischet contributed towards a physiographic analysis of Hudson-James bay lowland using Landsat satelite and aerial photos in combination with ground level field sampling. This was further explored in a paper by S. Pala and A. Boissonneau which provides a striking coloured map using digitally analyzed Landsat data. A practical application of computerized analysis is presented by N. Fortin and P. Legendre who employed minimal path analysis to select transportation corridors.

M. J. Dunbar reviewed oceanographic research which began in 1930 and whose pace has accelerated since. Winter data and productivity measurements during spring bloom maxima are largely lacking and vertical exchange is not yet fully understood. H. E. Sadler reported on water flow into Foxe Basin through Fury and Hecla Strait. Phase differences in tides give rise to rapid currents and polynyas. The net easterly transport (0.04×10^6 m^3/s) is small compared with Nares Strait and Lancaster Sound.

R. G. Ingram, in describing pre-impoundment Eastmain River tidal circulation, found that the river's plume into James Bay was longer and thicker under the ice in winter and early spring than during the ice-free period due to reduced turbulence and changes in flow at the river mouth. A second paper on river plumes by N. G. Freeman, J. C. Roff and R. J. Pett showed nutrient values to be low in the plume but relatively high in the surface ice and snow cover. According to R. J. Pett and J. C. Roff the deep waters of Hudson Bay are Arctic in type, circulate cyclonically, and turn over approximately every 4-14 years. Consequently, deep water mixing contributes only as much nitrates and total nitrogen as land runoff.

S. J. Prinsenberg found winter outflow of James Bay prior to hydroelectric developments to be one third that of summer. He predicted winter outflow would be doubled after hydroelectric developments. J. B. Sérodes suggested that decay of trees and flooded soils in new reservoirs would considerably elevate the dissolved oxygen demand. D. Roy's initial findings suggests that cutting of the winter flow of the La Grande Rivière did not significantly increase fish mortality.

A study by M. M. R. Freeman described ecological changes in two selected Inuit communities in the Hudson Bay region. Hunting remains a significant activity for economic and social reasons, in spite of these changes. He emphasized that biological consequences of altered hydrological conditions due to the James Bay power project will certainly produce system changes that will impact the human population. Often, "solutions" for northern communities are planned in, and imported from, the south. Seldom are native people brought into the centre of planning and decision making. Zimmermann *et al.* described an example where a northern community was involved in decision making for water and sanitation facilities. It is time that this approach was made the standard. It is notable that there were no presentations by Inuit or Indians in this publication.

The quality of the papers and the editing is unusually high. The papers are organized in meaningful patterns. The Universities of Laval and Guelph, and the authors are to be congratulated. The volumes provide a timely update and complement to the two volumes of *Science, History and Hudson Bay* published in 1968 by the Department of Energy, Mines and Resources, Ottawa. Whether the reader is interested in aquatic, terrestrial or marine environment of the Hudson or James Bay region I highly recommend adding these volumes to your organization's or your own library.

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MISCELLANEOUS

A Synoptic Classification of Living Organisms

Edited by R. S. K. Barnes. 1984. Sinauer Associates, Sunderland, Massachusetts. ix + 273 pp., illus. U.S.$11.50.

For a beginning student, the diversity of life can be overwhelming. Even advanced students and specialists are familiar only with a relatively small number of higher taxa. Major reference works are available that review the higher classification of organisms, but these are lengthy and expensive. Specialized works cover selected groups in considerable detail, but by design fail to treat other organisms. Several introductory textbooks treat the major divisions of organisms but are of limited scope. Thus, there is a need for a single inexpensive source that summarizes information on all major groups of organisms in a uniform and effective manner.

A Synoptic Classification of Living Organisms is such a book. In this reasonably priced paperback volume, Dr. Barnes and his four collaborators have managed to succinctly characterize all forms of life to the level of order; viruses and similar forms are not covered. The summary descriptions are presented in the form of an outline classification which features five kingdoms: Monera, Protista, Fungi, Plantae, and Animalia. The salient features of each kingdom, phylum, class, and order are presented in a brief synopsis with a very brief reference to other systems of classification when they differ from those used by the authors. Each phylum of eucaryotes is accompanied by one or two small, attractive line drawings of representatives of the phylum. The synoptic accounts under each taxon are brief and to the point, mentioning the characteristics that make each unique.

The classification scheme used by the authors is described in the introduction as a consensus of current thought, and reflects the uncertainty of the relationships among numerous groups. Within the Mammalia, for instance, the eutherian "orders" are treated as generally recognized groupings without formal taxonomic names. Also, the enigmatic lichens are given short shrift, being dismissed altogether except for incidental mention under Fungi and Plantae that certain of these organisms combine to form lichens. Some day, perhaps, biologists will recognize that lichens are unique, distinctive, valid organisms that need to be included in classification schemes. The reluctance of most scientists to do so at present is the result of the limitations of our concepts of species and classification, rather than the nature of the organisms themselves.

A Synoptic Classification of Living Organisms is a useful resource for students, teachers, and professionals. Not everyone will be satisfied with every aspect of the classification adopted, but the information is accurate and clearly presented.

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NEW TITLES

Zoology

Animal behaviour: volume 1 — causes and effects; volume 2 — communication; and volume 3 — genes, development, and learning. 1983. Edited by T. R. Halliday and P. J. B. Slater. Freeman, New York. ix + 228 pp., illus; ix + 225 pp., illus; and ix + 246 pp., illus. U.S.$14.95 each.

*__Arctic wildlife.__ 1984. By Monte Hummel. Key Porter Books, Toronto. 160 pp., illus. $29.95.

Bats: a natural history. 1984. By John E. Hill and James D. Smith. University of Texas Press, Austin. iv + 243 pp., illus. U.S.$24.95.

†**The biology of ground-dwelling squirrels: annual cycles, behavioral ecology, and sociality.** 1984. Edited by Jan O. Murie and Gail R. Michener. University of Nebraska Press, Lincoln. xvi + 459 pp., illus. U.S.$25.95.

*__The birds of China.__ 1984. By Rodolphe Meyer de Schauensee. Smithsonian Institute, Washington. 602 pp., illus. Cloth U.S. $45; paper U.S.$29.95.

†**The birds of Prince Edward County.** 1984. By R. Terry Sprague and Ron D. Weir. Kingston Field Naturalists, Kingston. xv + 190 pp., illus. $19.

Bird sounds and their meaning. 1984. By Rosemary Jellis. Reprint of 1977 edition. Cornell University Press, Ithaca. 256 pp., illus. U.S.$14.95.

Butterflies east of the Great Plains: an illustrated natural history. 1984. By Paul A. Opler and George O. Krizek. Johns Hopkins University Press, Baltimore. xviii + 294 pp., illus. + plates. U.S.$38.

Dam design and operation to optimize fish production in impounded river basins. 1984. By the F. A. O. Renouf, Ottawa. 98 pp. $7.50.

***The ecology of aquatic insects.** 1984. Edited by Vincent A. Resh and David M. Rosenberg. Praeger, New York. x + 625 pp., illus. U.S.$35.

Evolutionary ecology of marsupials. 1985. By A. K. Lee and Andrew Cockburn. Cambridge University Press, New York. c300 pp., cU.S.$49.50.

Evolutionary genetics of fishes. 1984. Edited by Bruce J. Turner. Plenum, New York. xx + 636 pp., illus. U.S.$85.

Freshwater fisheries management. 1984. By the F. A. O. Renouf, Ottawa. 192 pp. $28.50.

A field guide to the warblers of Britain and Europe. 1983. By Alick Moore. Oxford University Press, New York. xiv + 145 pp., illus. + plates. U.S.$18.95.

***Introduction to Canadian amphibians and reptiles.** 1984. By Francis R. Cook. National Museum of Natural Sciences, Ottawa. 200 pp., illus. (also available in French). $12.95.

Introduction to fisheries management: advantages, difficulties, and mechanisms. 1984. By the F. A. O. Technical Paper No. 224. Renouf, Ottawa. 58 pp. $7.50.

Marine biology. 1984. By Harold V. Thurman and Herbert H. Webber. Merill (Bell and Howell), Columbus, Ohio. xiv + 446 pp., illus. + plates. U.S.$27.95.

Orders and families of recent mammals of the world. 1984. Edited by Sydney Anderson and J. Knox Jones Jr. Wiley-Interscience, New York. xiv + 686 pp., illus. U.S.$54.95.

The owl papers. 1983. By Jonathan Evan Maslow. Dutton, New York. 184 pp., illus. U.S.$17.95.

Owls of Britain and Europe. 1984. By A. A. Wardhaugh. Blandford (Distributed by Sterling, New York). 128 pp., illus. U.S.$16.95.

***The puffin.** 1984. By M. P. Harris. Buteo, Vermillion, South Dakota. 224 pp., illus. U.S.$32.50.

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ISSN 0008-3550

The CANADIAN FIELD-NATURALIST

Published by THE OTTAWA FIELD-NATURALISTS' CLUB, Ottawa, Canada

Volume 99, Number 4

October-December 1985

The Canadian Field-Naturalist

The Canadian Field-Naturalist is published quarterly by The Ottawa Field-Naturalists' Club. Opinions and ideas expressed in this journal do not necessarily reflect those of The Ottawa Field-Naturalists' Club or any other agency.

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Subscription rates for individuals are $17 per calendar year. Libraries and other institutions may subscribe at the rate of $30 per year (volume). The Ottawa Field-Naturalists' Club annual membership fee of $17 includes a subscription to *The Canadian Field-Naturalist*. Subscriptions, applications for membership, notices of changes of address, and undeliverable copies should be mailed to: The Ottawa Field-Naturalists' Club, Box 3264, Postal Station C, Ottawa, Canada K1Y 4J5.

Second Class Mail Registration No. 0527 — Return Postage Guaranteed.

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Cover: Habitat structure within different stages of Jack Pine forests in northeastern Ontario: (left) recently burned, (center) 40-year-old forest, (right) 60-year-old mixed forest. See article on density of Heather Voles, *Phenocomys intermedius*, by B. J. Naylor, J.F. Bendell, and S. Spires, pp. 494-497.

The Canadian Field-Naturalist

Volume 99, Number 4 October-December 1985

Observations on the Annual Chronology for Birds in the Warden's Grove Area, Thelon River, Northwest Territories, 1977-1978

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Norment, Christopher J. 1985. Observations on the annual chronology for birds in the Warden's Grove area, Thelon River, Northwest Territories, 1977–1978. Canadian Field-Naturalist 99(4): 471–483.

In 1977 and 1978, observations were made on the annual chronology for birds in the Thelon River area, Northwest Territories. A total of 44 species was observed in the fall of 1977 (15 August-31 October). Some breeding species had already departed from the study area prior to 15 August, but the last migrants did not leave until the end of October. Of seven species observed during the winter (1 November-30 April), only Willow Ptarmigan (*Lagopus lagopus*), Rock Ptarmigan (*Lagopus mutus*), and Gray Jays (*Perisoreus canadensis*) were seen throughout the period. In the spring of 1978 (1 May-15 June), 61 species were observed. The first migrants began arriving shortly after the beginning of thaw on 29 April. Most species dependent on aquatic or streamside habitats did not arrive until open water appeared in late May. Numbers and frequency of observation for species seen during both the fall and spring were generally higher in the spring. A total of 69 species was observed during the summer of 1978 (16 June-16 July). The earliest breeding species in the study area were the Common Raven (*Corvus corax*) and Gyrfalcon (*Falco rusticolus*). Most passerines appeared to fledge young during the second half of July. Inclement weather during the spring and summer appeared to affect populations of breeding passerines negatively, but its effect on breeding and migration chronologies is unclear.

Key Words: Northwest Territories, Thelon Game Sanctuary, breeding chronology, migration, avifauna, mortality.

The barrenlands and tundra-boreal forest ecotone of the mainland Northwest Territories cover an area of c. 840 000 km^2 situated between Hudson Bay to the east, the boreal forests of Manitoba and Saskatchewan to the south, the Mackenzie drainage to the west, and the Arctic Ocean to the north. The isolation and severe weather that characterize the interior portions of that region have limited ornithological research there, and its avifauna is known primarily from studies conducted during the moderate summers (Clarke 1940; Manning 1948; Harper 1953; Mowat and Lawrie 1955; Kuyt 1980). There appear to be no published, systematic records of bird observations made throughout the year in the barrenlands or tundra-forest ecotone of the Northwest Territories (E. Kuyt, Canadian Wildlife Service, personal communication).

This paper summarizes information on the fall and spring migrations, wintering birds and summer birds between 15 August 1977 and 16 July 1978, while I resided in the Thelon Game Sanctuary (here after referred to as TGS). The TGS is a 31 000 km^2 area in the central barrenlands established in 1927 to protect the largest remaining mainland herd of Muskoxen (*Ovibos moschatus*). I stayed in the TGS and surrounding area continuously except for nine days between 29 January and 6 February 1978.

Study Area

The study area includes portions of the Thelon River system between Eyeberry Lake and Beverly Lake, and the Hanbury River between Deville Lake and its junction with the Thelon River (Figure 1). Most observations were made within 20 km of Warden's Grove (63°41′N, 104°26′W; hereafter referred to as WG), a 7 ha stand of White and Black Spruce (*Picea glauca* and *P. mariana*) in the southwestern portion of the TGS which served as a base camp from 20 August 1977 through 8 July 1978. The habitats and physiography of the TGS and surrounding areas have been described in detail (Bird 1951, 1967; Kuyt 1972, 1980) and will be discussed only briefly. Portions of the region lie within the Kazan Upland and Thelon Plain physiographic divisions of the Canadian Shield (Clayton et al. 1977), with the granitic and gneissic uplands of the Hanbury drainage giving way to a till-covered plain of low relief in the middle Thelon Basin (Bird 1951). The topography of the area around WG consists mainly of rocky, glaciated hills below 180 m dissected by numerous swales, lakes, and streams; to the east are large expanses of gently rolling tundra. The Thelon River flows northeast past WG and Grassy Island, a broad, willow-covered flat with good waterfowl habitat.

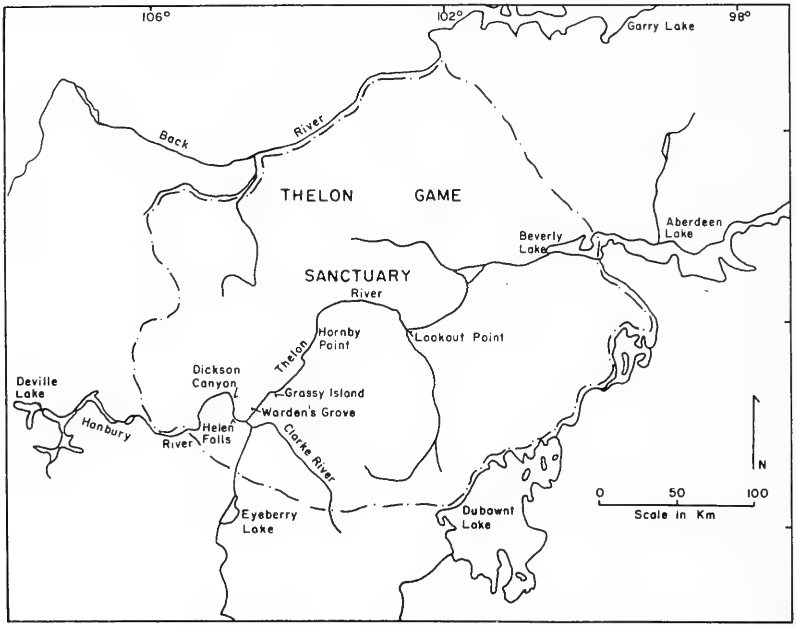

FIGURE 1. Map of the Thelon Game Sanctuary and surrounding areas.

The Thelon River Valley supports extensive stands of White and Black Spruce growing in sheltered locations beyond the northern forest border. This "tree island", a probable relict of warmer Holocene summers (Nichols 1976), is surrounded on three sides by the barrenlands and connected to the continuous boreal forest to the south by only scattered spruce stands (Clarke 1940). Five plant communities similar to those described by Larsen (1965, 1971) are common: rockfield, tussock muskeg, low *Carex* meadow, upland Black Spruce, and lowland Black Spruce. A mixed White Spruce-Black Spruce community occurs on well-drained sites. The distribution of spruce in the TGS is discontinuous, with stands of 0.1 to 10 ha occurring along drainages, beach strands, and dunes.

Climate and Phenology

The study area lies near the border between the arctic and boreal climatic regions of Canada (Hare and Thomas 1974). The climate is characterized by long cold winters, short, generally cool summers, and variable weather patterns. Scattered climatological data exist for the TGS and surrounding area (early records summarized by Clarke 1940), but meteorological observations made at WG represent the only relatively complete records for the area during the fall, winter, and spring (Table 1). The weather stations nearest to WG and within the barrenlands are Contwoyto Lake, 350 km to the northwest, and Ennadai Lake, 350 km to the southeast. The following description of the climate is based on observations made at WG in 1977 and 1978.

Calm weather and above-freezing temperatures prevailed during August and September, although some snow fell on 13 September. Temperatures began falling in October; the Thelon River was choked with ice on 11 October and all leads disappeared by 20 October. All lakes were ice-covered by 1 November. Frequent storms occurred during October, November, and December; 125 cm of snow fell during these months. Temperatures were 2–3°C above long-term means over the central barrenlands during September and October 1977, and 3–7°C above normal during January and February 1978 (Atmospheric Environment Service 1977, 1978a).

Melt began on 29 April, and large patches of snow-free tundra were present by 15 May. Most snow had disappeared by early June, although drifts persisted in protected areas until late June. Weather conditions were extremely variable throughout the spring, with periods of warming interspersed between violent storms lasting 3–5 d. The first indices of renewed plant growth appeared in mid-May; cottongrass (*Eriophorum spissum*) was in flower by 14 May, although most species did not exhibit obvious signs of growth until early June. Mean daily temperatures rose above freezing in June.

Open leads of water appeared along the margins of

TABLE 1. Summary of weather data recorded at Warden's Grove, Thelon Game Sanctuary, Northwest Territories, September 1977-June 1978.

Month	Temperature extremes (°C) Max.	Min.	Mean temperature (°C)	Mean wind speed (km/h)	Total precipitation (mm)	Snow depth at month's end (cm)
Sept. 1977*	17.5	-4.0	5.5	5.4	20.0	0
Oct. 1977	8.8	-21.2	-5.7	8.0	47.6	34
Nov. 1977	-0.2	-39.9	-20.0	10.0	44.3	42
Dec. 1977	-7.6	-42.1	-28.9	10.9	33.6	75
Jan. 1978**	-10.8	-42.6	-29.5	8.9	1.0	56
Feb. 1978***	-3.0	-40.5	-23.9	11.4	13.8	77
Mar. 1978	-16.0	-40.5	-27.0	6.0	5.8	72
Apr. 1978	2.8	-34.3	-16.3	19.2	20.0	64
May 1978	10.4	-21.5	-4.1	13.2	17.2	6
June 1978	22.5	-6.0	4.8	12.2	27.8	0

* 27 days.
** 29 days.
***22 days.

the Thelon River and smaller tundra ponds in late May, providing the first available habitat for arriving waterfowl and waders. Peak runoff occurred in mid-June, and the Thelon River "went out" on 14 June. Although smaller lakes and ponds were ice-free by mid-June, ice remained on the larger lakes until the end of July.

The spring and summer of 1978 were cooler than normal; temperatures were 1–2°C below normal over the central barrenlands during April and May and 3–4°C below normal during June and July. Precipitation was 150–200% above normal at several stations (AES 1978a). Snow fell at WG in June and July, and heavy winter pack ice remained on Northwest Territories waters later than normal (AES 1978b). Cone production by White and Black spruce in the TGS was minimal in 1978, in contrast to the abundant crops produced during the summer of 1977 (personal observation).

Avifaunal Observations

The following chronological treatment is based on observations of 80 speices made during residency at WG and extensive travels into surrounding areas on foot, by canoe, and dog team. For purposes of discussion, the period of observation is divided into four segments: fall (15 August-31 October); winter (1 November-30 April); spring (1 May-15 June); and summer (16 June-16 July). Those divisions were selected to correspond with weather patterns, timing of ice and snow melt and deposition, and migration chronology. Bird observations were recorded on 39 dates in the fall, 75 dates in the winter, 39 dates in the spring, and 24 dates in the summer. Inclement weather, additional duties, and a 9-day absence between 29 January and 6 February 1978 precluded field work on many days of the 11 month period.

Whenever possible, observations made during the present study are compared with the sporadic fall, winter, and spring records of Christian (1937), Hoare (summarized by Clarke 1940), and Critchell-Bullock (1931). Christian spent the winter of 1926–1927 at Hornby Point, 50 km northeast of WG, while Hoare wintered at WG in 1928–1929. Critchell-Bullock spent the winter of 1924–1925 near the north end of Artillery Lake, about 150 km southwest of WG, and descended the Hanbury-Thelon Rivers the following summer. His list of bird observations was more extensive than either Christian's or Hoare's, but nevertheless incomplete. Comparisons are also made with the records of Harper (1953) and Mowat and Lawrie (1955), who spent considerable time in 1947 and 1948 in the vicinity of Nueltin Lake-Windy River, Keewatin, a boreal forest-tundra ecotone station 450 km southeast of WG. Lawrie was also active at Beverly Lake in June and July 1949.

Fall

A total of 44 species was observed between 15 August and 31 October 1977 (Table 2). Five species observed during the fall were not recorded during the following spring and summer: Baird's Sandpiper, Pectoral Sandpiper, Yellow-bellied Sapsucker, Chipping Sparrow, and Dark-eyed Junco (scientific names given in Table 2). Numbers and observation frequencies of species seen during both the fall and spring were generally greater in the spring.

Many species which utilize the Thelon River Valley during the summer had departed prior to my arrival at WG on 20 August. Omnivorous or insectivorous pas-

TABLE 2. Seasonal summary of bird observations, Thelon River area, Northwest Territories, 15 August 1977-16 July 1978. Fall = 15 August-31 October; winter = 1 November-30 April; spring = 1 May-15 June; summer = 16 June-16 July.

Species	Fall (39 d)		Winter (75 d)		Spring (39 d)		Summer (24 d)		Departure date[3]	Arrival date[4]
	F[1]	Max.[2]	F	Max.	F	Max.	F	Max.		
Red-throated Loon *Gavia stellata*					2	2	3	2		10 June
Arctic Loon *Gavia arctica*					4	8	8	8		7 June
Common Loon *Gavia immer*	2	1			1	1	1	1	7 Oct.	11 June
Yellow-billed Loon *Gavia adamsii*	1	3			5	5	3	4	15 Aug.	30 May
Tundra Swan *Cygnus columbianus**	7	5			11	20	10	15	7 Oct.	20 May
Greater White-fronted Goose *Anser albifrons*	2	10			9	150±	1	2	16 Aug.	17 May
Snow Goose *Chen caerulescens*					9	2000±	1	1		18 May
Ross' Goose *Chen rossii*					2	400±				30 May
Canada Goose *Branta canadensis*	7	30			15	300±	6	400±	6 Oct.	13 May
Green-winged Teal *Anas crecca*	1	2			3	1	7	12	24 Sept.	10 June
American Black Duck *Anas rubripes*							1	2		
Mallard *Anas platyrhynchos*	2	20			1	1	2	6	5 Oct.	10 June
Northern Pintail *Anas acuta*	1	1			7	60	9	50	18 Aug.	26 May
American Wigeon *Anas americana*					4	4	5	8		7 June
Scaup *Aythya* sp.?	1	3			3	8	5	8	24 Sept.	30 May
Oldsquaw *Clangula hyemalis*	1	6			5	50	12	30	24 Sept.	30 May
Surf Scoter *Melanitta perspicillata*							3	12		
White-winged Scoter *Melanitta fusca*					3	4	5	8		8 June
Common Goldeneye *Bucephala clangula*							1	1		
Common Merganser *Mergus merganser*					2	3	5	15		3 June
Red-breasted Merganser *Mergus serrator**	6	30			7	8	14	30	5 Oct.	30 May
Bald Eagle *Haliaeetus leucocephalus*							1	1		
Northern Harrier *Circus cyaneus*	2	1			1	1	1	2	20 Aug.	26 May
Northern Goshawk *Accipiter gentilis*	2	1					1	1	5 Oct.	
Rough-legged Hawk *Buteo lagopus**	5	3			15	6	5	4	24 Sept.	3 May
Golden Eagle *Aquila chrysaetos*	1	1					2	3	7 Oct.	
Merlin *Falco columbarius*					3	2				21 May
Peregrine Falcon *Falco peregrinus**	9	3			7	3	2	2	21 Sept.	18 May
Gyrfalcon *Falco rusticolus**	3	3	3	2	5	2	2	3		
Willow Ptarmigan *Lagopus lagopus**	10	150±	41	20	26	20	15	10		
Rock Ptarmigan *Lagopus mutus*	2	6	10	10	2	10				
Sandhill Crane *Grus canadensis*	3	20			15	50±	2	3	25 Sept.	7 May
Lesser Golden Plover *Pluvialis dominica*					3	15	3	4		3 June
Semipalmated Plover *Charadrius semipalmatus*					5	4	3	2		28 May
Lesser Yellowlegs *Tringa flavipes*							4	6		28 June
Spotted Sandpiper *Actitis macularia*							1	3		
Ruddy Turnstone *Arenaria interpres*							3	4		19 June
Sanderling *Calidris alba*	1	2					3	4	24 Sept.	19 June
Semipalmated Sandpiper *Calidris pusilla*					8	10	4	10		30 May
Least Sandpiper *Calidris minutilla*					9	15	4	20		28 May
White-rumped Sandpiper *Calidris fuscicollis*					2	1	4	4		10 June

TABLE 2. Seasonal summary of bird observations (*continued*)

Species	Fall (39 d)		Winter (75 d)		Spring (39 d)		Summer (24 d)		Departure date[3]	Arrival date[4]
	F[1]	Max.[2]	F	Max.	F	Max.	F	Max.		
Baird's Sandpiper *Calidris bairdii*	1	3							18 Aug.	
Pectoral Sandpiper *Calidris melanotos*	1	1							24 Sept.	
Dunlin *Calidris alpina*							1	2		20 June
Common Snipe *Gallinago gallinago*	1	1			1	1	3	4	18 Aug.	11 June
Red-necked Phalarope *Phalaropus lobatus*					1	1	5	100±		11 June
Red Phalarope *Phalaropus fulicaria*					1	2	3	1		8 June
Parasitic Jaeger *Stercorarius parasiticus*					5	2	3	10		31 May
Long-tailed Jaeger *Stercorarius longicaudus*	1	2					5	3	15 Aug.	19 June
Bonaparte's Gull *Larus philadelphia*							1	2		
Mew Gull *Larus canus*					5	3	3	2		23 May
Herring Gull *Larus argentatus*	7	10			11	10	12	30	7 Oct.	6 May
Arctic Tern *Sterna paradisaea*	1	4					12	150±	18 Aug.	20 June
Short-eared Owl *Asio flammeus**	1	2			5	1	2	3	23 Sept.	30 May
Yellow-bellied Sapsucker *Sphyrapicus varius*	2	1							30 Sept.	
Horned Lark *Eremophila alpestris**	1	1			6	50	4	6	19 Aug.	14 May
Cliff Swallow *Hirundo pyrrhonota**					4	2	8	100±		28 May
Barn Swallow *Hirundo rustica*					1	2				4 May
Gray Jay *Perisoreus canadensis**	15	4	38	4	17	7	6	4		
Common Raven *Corvus corax**	16	6	13	4	12	6	9	15		
Gray-cheeked Thrush *Catharus minimus**					9	6	13	4		1 June
American Robin *Turdus migratorius**	13	25			16	20	18	10	13 Oct.	13 May
Water Pipit *Anthus spinoletta**	1	1			1	2	2	1	3 Sept.	14 June
Northern Shrike *Lanius excubitor**	7	3			7	1	3	2	25 Sept.	6 May
Yellow-rumped Warbler *Dendroica coronata*					7	3	3	6		31 May
Blackpoll Warbler *Dendroica striata*					6	5	15	16		4 June
American Tree Sparrow *Spizella arborea**	9	22			14	10	18	25	25 Sept.	19 May
Chipping Sparrow *Spizella passerina*	1	1							18 Aug.	
Savannah Sparrow *Passerculus sandwichensis*					5	1	5	4		7 June
Fox Sparrow *Passerella iliaca*					1	1	1	1		29 May
White-crowned Sparrow *Zonotrichia leucophrys**	3	5			11	5	16	7	3 Sept.	21 May
Harris' Sparrow *Zonotrichia querula**	6	15			12	20	20	26	9 Sept.	26 May
Dark-eyed Junco *Junco hyemalis*	4	4							31 Oct.	
Lapland Longspur *Calcarius lapponicus**	6	30			5	15	7	6	23 Sept.	17 May
Snow Bunting *Plectrophenax nivalis*	6	100±			8	100±			29 Oct.	1 May
Rusty Blackbird *Euphagus carolinus**					8	5	6	24		21 May
Pine Grosbeak *Pinicola enucleator*					2	1				26 May
White-winged Crossbill *Loxia leucoptera*	1	6	28	30	3	4	10	5		
Redpoll *Carduelis* sp. ?	14	40	2	16						

TABLE 2. (*Continued*)

TABLE 2. Seasonal summary of bird observations (*concluded*)

Species	Fall (39 d)		Winter (75 d)		Spring (39 d)		Summer (24 d)		Departure date[3]	Arrival date[4]
	F[1]	Max.[2]	F	Max.	F	Max.	F	Max.		
Common Redpoll *Carduelis flammea**					7	30	7	4		2 May
Hoary Redpoll *Carduelis hornemanni**					12	4	9	6		12 May
Total Species	44		7		61		69			

[1]F = Number of days observed.
[2]Max. = Maximum number of individuals observed on any one day.
[3]In fall of 1977.
[4]In spring of 1978.
*Species which bred in the TGS in 1977–1978 (eggs, nestlings, or fledged young observed.)

serines such as the Cliff Swallow, Gray-cheeked Thrush, Yellow-rumped Warbler, and Blackpoll Warbler were not observed, and eight species noted on the Hanbury River between 15 and 19 August were not seen later (Table 2).

I observed no concentrated migration of aquatic species or shorebirds during the fall; various species were last observed in August, September, or early October. The last species to depart were the Common Loon, Tundra Swan, Canada Goose, Mallard, Red-breasted Merganser, and Herring Gull, all noted between 5 and 7 October near Grassy Island. The Canada Goose sighting was of a lone individual on 6 October; the last flocks had been noted on 7 September. Departure of the last waterfowl in 1977 was closely followed by the freezing of the Thelon River, which was choked with ice on 11 October. Tundra Swans and Red-breasted Mergansers were the last aquatic species to leave the Windy River area in 1947 and 1948 (Harper 1953; Mowat and Lawrie 1955), and Herring Gulls were the last primarily aquatic species observed by Critchell-Bullock (1931).

Numbers and species of waterfowl (loons, swans, geese, and ducks) in the TGS area were lower during the fall (11 species) than the following spring (18 species), as found by Mowat and Lawrie (1955) and Critchell-Bullock (1931). In contrast to the frequent sightings of flocks of 50 or more individuals during the spring, most species of waterfowl were seen infrequently and in low numbers during the fall, and no flocks of more than 30 were observed. Most notable in its absence was the Snow Goose, 2000 of which were seen on a single day the following spring. Migration records show departure dates from the arctic breeding grounds in September (Bellrose 1976), and Snow Geese should have been observed if they passed over the Thelon River Valley during daylight hours in the fall of 1977.

Numbers and species of sandpipers, plovers, and phalaropes were also lower in the fall. Only eight individuals of four species were seen, in contrast to eight species and up to 25 individuals/day during the summer. Mowat and Lawrie (1955) and Harper (1953) each recorded only five species in 1948 and 1947 respectively. These observations suggest that many shorebirds depart from the central barrenlands by mid-August, and that the area between the Thelon River and Nueltin Lake may not be used as a major fall staging area by species breeding in the Canadian Arctic.

Most breeding passerines had departed by late September (Table 2), although above-freezing temperatures and calm weather conditions persisted until 8 October. Most American Robins, one of the most abundant fall passerines, had departed by 25 Sep-

tember, although a few remained until 13 October. The remaining migrant passerines departed in October, following a deterioration in weather conditions which brought temperatures of -21° C and 47 cm of snowfall by the end of the month. Redpolls (*Carduelis* sp. ?), common throughout the fall, were last observed on 20 October. Snow Buntings, first seen on 4 October, were present in flocks of 10–100 on the tundra and sedge-covered banks of the Thelon River until 29 October.

Three winter residents were first seen in October: Gyrfalcons on 5 October, White-winged Crossbills on 19 October, and Rock Ptarmigan on 20 October. Willow Ptarmigan were around WG throughout the fall, with fewer after 20 October. The transition from autumn to winter plumage was noticeable after 1 October. Flocks of 100 or more ptarmigan were seen between 25 September and 20 October, probably being birds moving southward into the boreal forest (see Harper 1953; Mowat and Lawrie 1955).

Three species seen in the TGS during the fall probably moved northward from boreal forest breeding grounds. Solitary Northern Goshawks were seen at Grassy Island on 24 September and Hornby Point on 5 October, and Dark-eyed Juncos were counted in small numbers ($< 5/d$) on four dates between 10–31 October. Mowat and Lawrie (1955) also observed influxes of goshawks and juncos at Windy River in September and October 1948, and Harper (1953) noted increased numbers of goshawks at Windy River in the fall of 1947. A solitary, immature male Yellow-bellied Sapsucker in the spruce at WG on 19 and 30 September is unusual as there are no published records of woodpeckers for the TGS or surrounding areas, and the nearest breeding records are 450 km to the south (Godfrey 1966).

Winter

Seven species were observed between 1 November 1977 and 30 April 1978. Willow Ptarmigan, Rock Ptarmigan, and Gray Jays were observed continously throughout the winter. The other four species were observed on only seven dates between 1 December and 15 February, but became more common later. Although weather conditions began moderating in early April, no influx of migratory species was noted until after 1 May.

Gyrfalcons overwinter in some northern areas (Platt 1976), and they were seen in the TGS on 6 January, 23 February, and 21 March 1978; the remains of a ptarmigan (*Lagopus* sp. ?) were found beneath a perch on a south-facing sandstone cliff along the Clarke River on 23 February. Critchell-Bullock (1931) saw a Gyrfalcon near Artillery Lake on 25 February 1925 and Christian (1937) may have seen one near Hornby Point during the winter of 1926–1927. They have also been observed in midwinter just south of the TGS (Kuyt 1980).

Willow and Rock ptarmigans were sympatric in the TGS during the winter, and were occasionally found together in the same habitats. However, the Willow Ptarmigan appeared to be more common in spruce-willow thickets along major rivers, whereas birds identifiable as Rock Ptarmigan were more frequently noted in more exposed locations on the tundra, often in or near clumps of Dwarf Birch (*Betula glandulosa*). The occurrence of those two species together (Clarke 1940; Porsild 1943), and in similar habitats (Harper 1953) has been noted elsewhere in the boreal forest-tundra ecotone. Conversely, Critchell-Bullock (1931) found only Rock Ptarmigan at the north end of Artillery Lake after 15 October 1924, where spruce are present in only small, scattered clumps (Larsen 1971). Willow Ptarmigan were generally in larger flocks ($\leqslant 25$) than Rock Ptarmigan ($\leqslant 10$) during the winter. Rock Ptarmigan were not seen around WG after 1 May 1978.

Common Ravens were observed in every month except December, but most sightings were in early November and April, corresponding with increased movement of Caribou (*Rangifer tarandus*) through the area. Ravens often feed on Caribou carcasses (Kelsall 1968), and the presence of ravens in the southern Keewatin and northern Manitoba has been related to Caribou movements (Harper 1953; Mowat and Lawrie 1955).

Gray Jays were the most commonly observed winter resident (Table 2), and many stands of spruce $\geqslant 5$ ha supported several birds during the winter. Christian (1937) saw wintering Gray Jays at Hornby Point in 1926–1927.

Groups of 10–16 redpolls, unidentified to species, were feeding on exposed sedge heads at Grassy Island on 17 January 1978, and on spruce cones at WG on 5 March 1978 in a mixed flock with White-winged Crossbills. No winter records of redpolls were reported by Critchell-Bullock (1931), Clarke (1940), or Mowat and Lawrie (1955), but Harper (1953) reported redpolls near Windy River in March 1947 and 1948.

White-winged Crossbills were relatively common in the TGS during the winter, although numbers were localized and appeared to fluctuate. From late October through January, flocks of 20–30 crossbills were occasionally seen at WG; they would remain for 1–2 days and depart, only to reappear 1–2 weeks later. Beginning in February, crossbills became permanent residents around WG. Males began singing on 20 February, and male-female pairs were noted in early March. However, no other signs of breeding were observed until 11 June, when a female was seen

carrying nesting material. Flocks of first-year males appeared sporadically during March and April. Christian (1937) reported crossbills at Hornby Point on 4 December 1926. It seems likely that the species breeds occasionally in the TGS and surrounding area, but its presence may be irregular, as its movements are related to the abundance of conifer seeds (Bock and Lepthien 1976), and cone production in the boreal forest-tundra ecotone is sporadic (Nichols 1976; personal observation).

Spring and Summer

A total of 61 species was observed between 1 May-15 June 1978, compared to 69 species between 16 June and 16 July 1978 (Table 2). Altogether, 70 species were observed in the vicinity of WG between 1 May and 8 July, and five other species were observed enroute from Grassy Island to Beverly Lake 9–16 July: one Common Goldeneye near Lookout Point, a total of 16 Surf Scoters, one Northern Goshawk below Grassy Island, one Bald Eagle 8 km below Hornby Point, and two Bonaparte's Gulls near Lookout Point.

The arrival of the first migrant species occurred shortly after the first thaw of the year on 19 April (Table 2). Flocks of Snow Buntings were observed on 1 May, and Rough-legged Hawks on 3 May. Other early arrivals included the Herring Gull and Northern Shrike on 6 May, and Sandhill Cranes on 7 May. Rough-legged Hawks, Sandhill Cranes, and Snow Buntings were among the earliest arrivals at the north end of Artillery Lake in 1925 (Critchell-Bullock 1931). Two Barn Swallows at WG on 4 May, in the aftermath of a 3-day storm, were unusual. The nearest breeding records are at Great Slave Lake (Godfrey 1966), although the species has wandered north to Cornwallis Island, N. W. T. (James and Barlow 1970). Another severe storm occurred 8–11 May, and no new migrant species were observed until 13 May. Thereafter, new arrivals occurred nearly every day during May.

Most species dependent on aquatic or stream-lakeside habitats during the breeding season did not arrive until open water appeared on the Thelon River and small tundra ponds in late May (Table 2); exceptions were swans and geese. Numbers of Canada Geese and Greater White-fronted Geese peaked between 15–21 May, whereas Snow Geese numbers peaked two weeks later (Figure 2). On 30 May, 2000 Snow Geese were in marshes between the Hanbury River and WG. On the same day, a flock of 400 Ross' Goose were observed in a marshy area near Helen Falls on the Hanbury River. Observation of Ross' Goose in the TGS in late May correlates well with its arrival on the Perry River nesting grounds 450 km to the north during the first week in June (Ryder 1967).

Ducks began to appear at the end of May; a broad peak in numbers occurred 29 May-11 June (Figure 3). Northern Pintails were first noted on 26 May, with scaup (*Aythya* sp. ?), Oldsquaws, and Red-breasted Mergansers first observed on 30 May. Pintails and Red-breasted Mergansers were the first ducks noted at Windy River in 1948 (Mowat and Lawrie 1955), and pintails were also the first ducks observed by Critchell-Bullock (1931) in 1925.

Although some snow-free ground was present from mid-May, no sandpipers or plovers were seen until 26 May (Table 2). Semipalmated Plovers, Semipalmated Sandpipers, and Least Sandpipers were the first waders observed during the spring, and the most common (Table 2), as noted by Critchell-Bullock (1931) and by Mowat and Lawrie (1955). Numbers of plovers and sandpipers peaked 19–25 June (Figure 3). Three species which breed to the north and east of WG were observed only during this period: Ruddy Turnstone, Sanderling, and Dunlin, all of which were observed also at Beverly Lake in June 1949 (Mowat and Lawrie 1955). Judging from observation dates, I doubt that Sanderlings observed in the TGS in 1978 were migrating breeders, as subadults occur south of the breeding range in the summr (Godfrey 1966).

Herring Gulls were seen two weeks earlier than reported by Critchell-Bullock (1931) in 1925, or by Hoare (in Clarke 1940) in 1929. Conversely, Arctic Terns were not noted until 20 June, 1–2 weeks later than reported by others (Critchell-Bullock 1931; Harper 1953; Mowat and Lawrie 1955).

First observation dates for passerines ranged from 1 May for Snow Buntings to 14 June for Water Pipits (Table 2). American Robins appeared on 13 May, but did not become common until after 20 May. Christian (1937) first saw robins at Hornby Point on 18 May 1927. Redpolls were observed on 2 May after a six-week absence from the WG area. American Tree Sparrows, White-crowned Sparrows, and Harris' Sparrows, three of the most common breeding species in spruce-willow stands around WG (unpublished data), arrived 19–26 May. Among the last passerines to arrive were several species that had departed from the WG area prior to our arrival on 20 August 1977: Gray-cheeked Thrushes on 1 June, Yellow-rumped Warblers on 31 May, and Blackpoll Warblers on 4 June. Arrival dates for those species were similar to those given by Mowat and Lawrie (1955) for Windy River in 1947 and 1948. Water Pipits were first seen 10 days later than reported by Mowat and Lawrie (1955) in 1947 and 22 days later than in 1948. Pipits have been described as abundant breeding birds in the barrenlands (Clarke 1940; Manning 1948; Mowat and Lawrie 1955), but were seen only once in the fall of 1977 and three times in 1978.

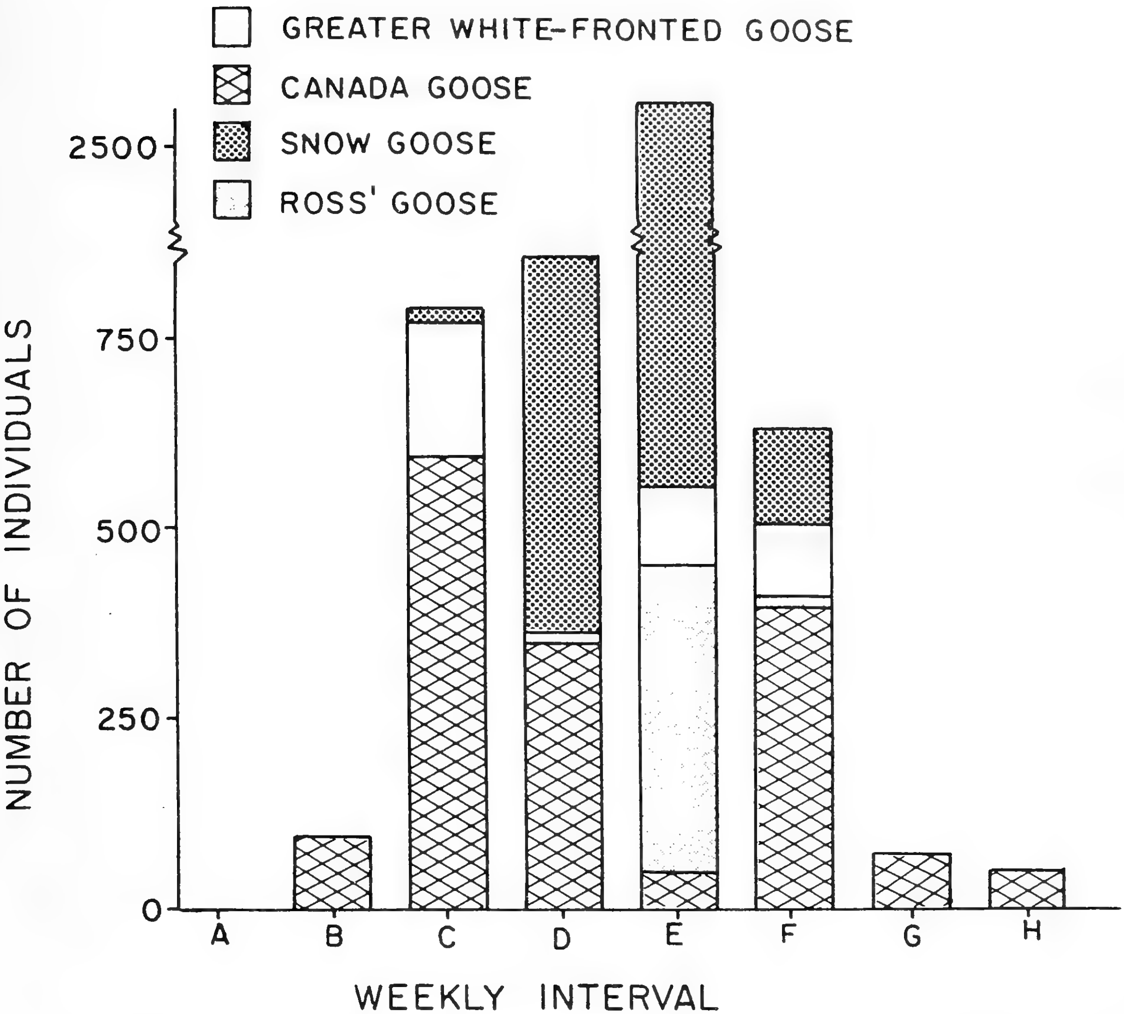

FIGURE 2. Weekly totals of geese counted in the Warden's Grove area, spring 1978. A = 1–7 May, B = 8–14 May, C = 15–21 May, D = 22–28 May, E = 29 May–4 June, F = 5–11 June, G = 12–18 June, H = 19–25 June, I = 12 June–2 July.

Unusual observations in the spring of 1978 included a female Pine Grosbeak feeding on *Arctostaphylos alpina* berries at the edge of WG on 26 May; another lone female was sighted on 6 June. Solitary Fox Sparrows were seen in spruce thickets on 29 May 1978 near Helen Falls, and below Grassy Island on 8 July. No evidence of breeding was noted for either species; the nearest breeding records are from Fort Reliance and Artillery Lake, respectively (Godfrey 1966).

Breeding Chronology

Ravens were the first species for which breeding activities were noted in the WG area. On 28 May, a pair was observed with three downy young at a nest on a south-facing cliff in Dickson Canyon. Assuming that the nestlings were 7-days old, and a 20-day incubation period (Godfrey 1966), egg-laying must have been completed about 2 May. Ravens are considered to be the first bird to nest in the Canadian arctic (Snyder 1957). Gyrfalcon nests containing three eggs each were found in Dickson Canyon on 27 May and near Helen Falls on 29 May. The latter nest contained three young approximately 7-days old on 25 June; assuming an incubation period of 29 days (Cade 1960), egg-laying was completed around 20 May, within the range of egg-laying dates estimated by Kuyt (1980) for Thelon River Gyrfalcons.

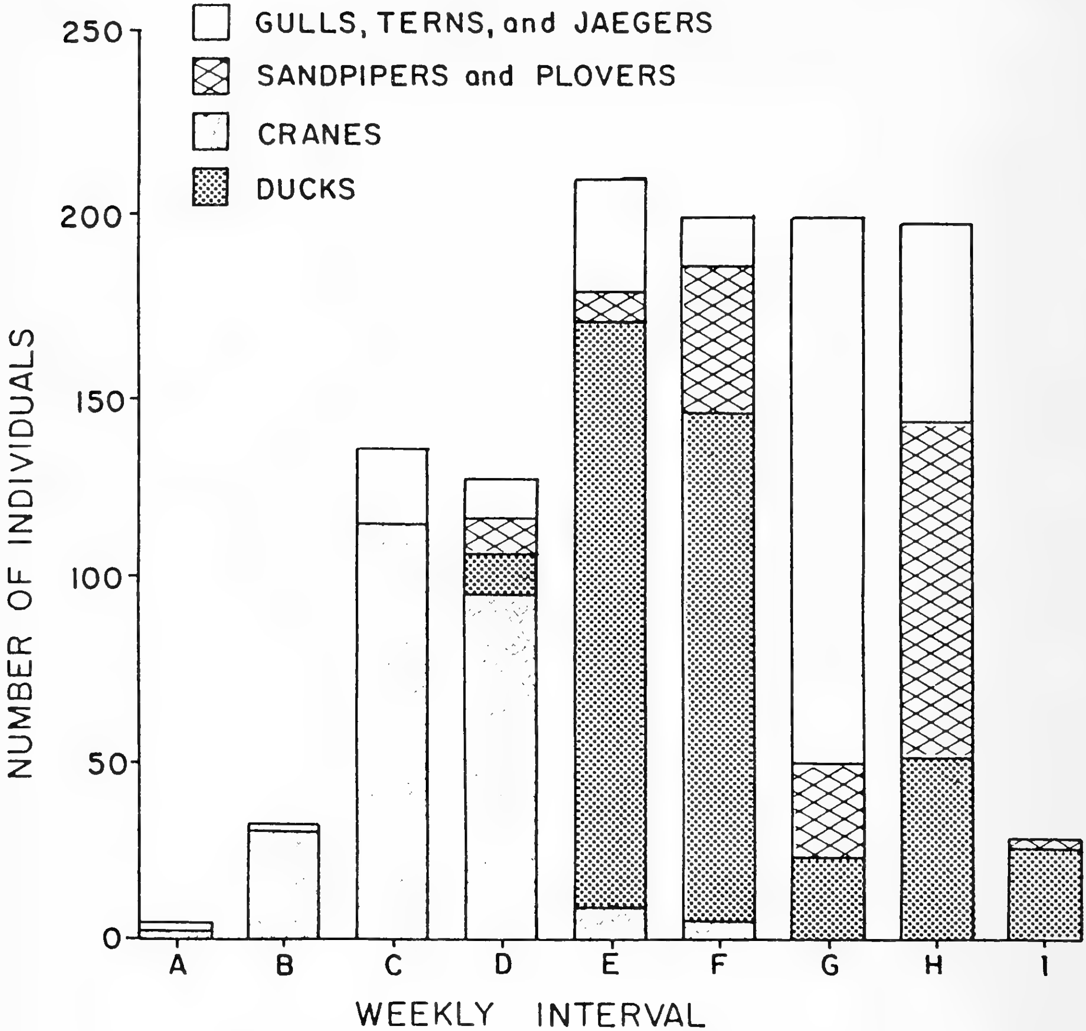

FIGURE 3. Weekly totals for selected groups of migratory birds in the Warden's Groove area, spring 1978. A = 1–7 May, B = 8–14 May, C = 15–21 May, D = 22–28 May, E = 29 May–4 June, F = 5–11 June, G = 12–18 June, H = 19–25 June, I = 26 June–2 July.

Other nesting raptors in the TGS included Rough-legged Hawks, Peregrine Falcons, and Short-eared Owls. I was unable to examine closely any Peregrine Falcon nesting sites, but a pair appeared to be occupying a nest on cliffs along the Hanbury River on 25 June; in the Thelon River area, the breeding cycle of peregrines is about 1 mo later than that of Gyrfalcons (Kuyt 1980). Rough-legged Hawks were observed on eggs on 28 May and 25 June 1978, within the range of dates reported by Kuyt (1980). A Short-eared Owl nest near Lookout Point contained two 1-day-old young and two pipping eggs on 12 July. Given an incubation period of 24–28 days (Witherby *in* Godfrey 1966), the eggs must have been laid 15–19 June, 2–3 weeks after the owls were first seen at WG.

Somewhat more complete observations were made on the breeding cycles of some passerines. Gray Jays had fledged young by 15 June, although newly-fledged young were also observed on 12 July. Among migrants, robins, redpolls, and tree sparrows were all seen building nests by 1 June. Both redpoll species initiated egg-laying by 5 June, robins by 12 June, and Horned Larks by 19 June. Redpolls are among the

TABLE 3. Comparison of spring arrival dates for migratory species at Warden's Grove in 1978 to those recorded at other boreal forest/tundra ecotone stations.

Source	Same arrival date (no. spp.)	Earlier arrival date (no. spp.)	Later arrival date (no. spp.)
Clarke (1940)*	1	3	9
Critchell-Bullock (1931)	1	6	11
Mowat and Lawrie (1955)			
1947	1	12	24
1948	1	20	11

*Does not include records of Critchell-Bullock (1931).

earliest nesters at Churchill, Manitoba (Jehl and Hussell 1966). The data on breeding chronology are incomplete due to our 8 July departure from WG. However, the available range of egg, nestling, and fledging dates (unpublished data) suggests that Horned Larks, robins, redpolls, and Rusty Blackbirds fledged young during the first two weeks of July, and other nesting passerines probably fledged young between 15 July and 1 August.

Unusual breeding records for the TGS included those for the Northern Shrike and Rusty Blackbird. A shrike nest with three eggs was found in a White Spruce 8 km north of WG on 24 June 1978, 250 km northeast of the breeding range as shown by Godfrey (1966), although breeding evidence is also available for Artillery Lake (E. Kuyt, Canadian Wildlife Service, personal communication). On 24 June, a male blackbird was observed carrying food 8 km northeast of WG; no nest could be located, but adults were seen feeding newly-fledged young on 12 July in the marshes near Lookout Point. Clarke (1940) noted the species as breeding near the eastern end of Great Slave Lake, and Godfrey (1966) listed it as a breeder at Nueltin Lake.

It is quite possible that below-normal temperatures, increased precipitation, and violent storms could have affected the migration and breeding chronology of birds in the TGS during the spring and summer of 1978. However, it is difficult to evaluate the extent to which weather patterns affected the chronologies of most species, as few data on the timing of migration and breeding in the Thelon River area are available for more than one year for most species (but see Kuyt 1980). Comparison of the 1978 data with the incomplete migration records available for other areas near the boreal forest-tundra ecotone showed no consistent differences; if anything, arrival dates were somewhat earlier in 1978 (Table 3). However, differing intensities of observation, the wide geographical separation between stations, and habitat differences may have affected the recorded arrival dates.

The limited data for the TGS area and apparent lack of any systematic variation in breeding chronology with geographic location in arctic passerines (Hussell 1972) make any statements about the effects of cooler weather upon breeding chronology risky. However, scattered records for the boreal forest-tundra ecotone give most initial dates for the observation of fledged young between 20 July and 5 August (Clarke 1940; Manning 1948; Harper 1953; Mowat and Lawrie 1955), similar to the fledging dates estimated for many passerines in the TGS area. The breeding chronologies of some arctic-breeding birds (Norton et al. 1975; Pattie 1977), but not all (Holmes 1966; Custer and Pitelka 1977) appear to be influenced by yearly differences in spring and summer weather patterns. In many birds, year-to-year variation in breeding chronologies in northern latitudes may be limited by synchronization of breeding cycles with long-term, "expected" peaks in arthropod abundance (Holmes 1966; Bunnell et al. 1975; Seastedt and MacLean 1979), and the need to complete the breeding cycle in a relatively short period of time. Passerines such as the Gray-cheeked Thrush, Yellow-rumped Warbler, and Blackpoll Warbler spend only 10–11 weeks on their breeding grounds in the TGS area. If young are to fledge and mature quickly enough to successfully complete migration, those species cannot prolong initiation of the breeding cycle for much more than 1 week, even in the face of inclement weather.

Even if weather patterns did not significantly affect the timing of migration and breeding, population levels seemed to be affected by the adverse weather. Between 16 and 19 June, a severe storm brought freezing rain and snow and winds above 110 km/h to WG. In the aftermath of the storm, 15 dead Horned Larks, Gray-cheeked Thrushes, and Lapland Longspurs were found near WG. Spot-map censuses (Williams 1936) conducted in mixed spruce stands of 6.8 and 5.3 ha before (n = 4) and after (n = 4) the storm indicated that breeding bird populations had decreased. Mean number of bird observations had decreased by 33% and 44% on the plots, while estimated numbers of breeding pairs showed corresponding decreases of 22% and 21% (unpublished data). Mean numbers of

non-territorial species (Hoary Redpolls, Common Redpolls, and White-winged Crossbills) also decreased by 58% and 48%. Insectivorous species appeared to be most affected; Yellow-rumped Warblers disappeared from both plots, and two pairs of Blackpoll Warblers disappeared from one. As pre-storm censuses were conducted between 5 June and 15 June, at least 10 days after the arrival of most species in the area (Table 2), and most males were singing and appeared to have established territories prior to the storm, pre- and post-storm differences were probably not due to migrating individuals which subsequently moved to other breeding locations. Rather, the storm and subsequent decline in breeding bird numbers appeared to be related.

Although there are few data on the effects of inclement weather on adult breeding passerines in arctic environments, severe weather may adversely affect populations of breeding adults in montane areas in North America (Eckhardt 1977). Inclement weather has also been shown to cause high rates of nestling mortality in arctic and subarctic passerines (Sutton and Parmelee 1954; Jehl and Hussell 1966).

Acknowledgments

I would like to thank the Fish and Wildlife Service of the Northwest Territories for allowing our party to travel and reside within the Thelon Game Sanctuary. The Land-Use Office of the Department of Natural and Cultural Affairs supplied the necessary land-use permit. E. Kuyt, D. Gray, and K. Bell all supplied useful information on the biota of the area. G. Anderson, R. Common, M. Mobley, and J. Mordhorst provided companionship in the field. Special thanks are due K. Mitchell for his cheerful assistance throughout our stay in the Thelon Game Sanctuary. R. Catling provided invaluable help with the logistics, and assisted in many other ways. R. E. Johnson, E. Kuyt, and A. J. Erskine reviewed various drafts of the manuscript; Kuyt also suggested a chronological approach for presenting the observations included here. This paper is dedicated to the memory of C. H. D. Clarke, a pioneer in biological research on the barrenlands.

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Received 27 October 1983
Accepted 2 October 1984

Nesting Habits and Activity Patterns of Warbling Vireos, *Vireo gilvus*, in Southern Ontario

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Male and female Warbling Vireos appeared to arrive at almost the same time in early May. Territorial interactions were infrequent. The female selected the nest-site, sometimes starting several nests before completing one. Females stole nesting material from the nests of conspecifics. During the nest-building period, males showed apparent guarding behaviour of the female and nest. Guarding may function to prevent cuckoldry, the stealing of nest material, predation, and increase the opportunity for copulation. Nest defence behaviour was greatest during the nest-building and fledgling periods. Both sexes shared in the incubation, brooding and feeding of the eggs and young. During the pre-nest-building period mates spent most of their time together. At each successive stage of the nesting cycle mates spent progressively less time together. The nesting habits and activity patterns of the Warbling Vireo were found to be more like those of the Philadelphia Vireo than of the Red-eyed Vireo.

Key Words: Warbling Vireo, *Vireo gilvus*, Red-eyed Vireo, *V. olivaceus*, Philadelphia Vireo, *V. philadelphicus*, Brown-headed Cowbird, *Molothrus ater*, *Vireoslyva*, southern Ontario, guarding, activity patterns, interactions.

The Warbling Vireo (*Vireo gilvus*) is a common resident mainly of mature open deciduous and mixed woodlands throughout much of southern Canada and of the continental United States, yet surprisingly little is known about the species' behaviour and breeding biology (Bent 1950; Godfrey 1966). References to the natural history of the Warbling Vireo are largely anecdotal (Buck 1896; Miller 1902; Rust 1920; Sutton 1949; Bent 1950; Riegel 1954; Dunham 1964; Salt 1973). Only the foraging behaviour and habitat of this species have been documented in some detail (Hamilton 1958, 1962; F. James 1971; R. James 1976; Whitmore 1975).

Between 1975 and 1977 I made observations on the natural history of Warbling Vireos in southern Ontario as part of an intensive study of the vocal communication system of the species (Howes-Jones 1982). This paper describes the activity patterns and behaviour of Warbling Vireos during the nesting cycle.

Methods

Warbling Vireos were studied in Cootes Paradise Sanctuary, Royal Botanical Gardens, Hamilton-Wentworth Rural Municipality, Hamilton, Ontario, from May to August in 1975 to 1977. In 1975, four pairs of birds were studied for 1 to 7.5 h each day. Supplementary observations of 5 to 20 min were made on another eight pairs. In 1976, seven pairs were studied for 1 h each day. Supplementary observations were made on another nine pairs. In 1977, four pairs were studied for at least 1 h each day. An attempt was made to visit each pair in the same time period each day. Behaviour and song activity were recorded in coded form on data sheets marked out in minutes and seconds. Distances between mates and the nest were determined by pacing. Sex determinations were based on behaviour and song. Males sang almost continuously throughout most of the nesting cycle.

I categorized activities of birds into eight contexts based on the proximity of a bird to its mate and nest. I selected the contexts and the distance of 10 m as the point beyond which a bird was considered distant (i.e. from the nest) or alone (i.e. from the mate) based on evidence gathered from studies of nest defence, courtship and vocal behaviour (Howes-Jones 1982). Generally, mates were either very close together (several meters apart) or were very far apart (much greater than 10 m). The contexts were selected to study for changes in behaviour and song structure. As males sang continuously, their activity patterns could be observed in detail, as one observer remained near the nest and the second observer (in 1976 and 1977) followed the male. Only occasional observations of females were made when they were away from the nest. Contexts included:

(1) Male-alone-distant — male more than 10 m from the nest or mate; included situations in which the male was alone prior to nest construction.
(2) Male-alone-near-the-nest — male within 10 m of the nest and alone.
(3) Male-on-the-nest — male sitting on nest.
(4) Male-female-near-the-nest — mates within 10 m of each other and the nest; female might be at the nest.

(5) Male-female-distant — mates together and more than 10 m from the nest; included situations in which pair was together prior to nest-building.
(6) Female-alone-near-the-nest — female within 10 m of the nest and alone.
(7) Female-alone-distant — female more than 10 m from nest and alone; included situations in which mated female was alone prior to nest construction.
(8) Female-on-the-nest — female sitting on nest, incubating, brooding or nest molding.

The time spent by individuals or pairs in each context was tallied for each period of the nesting cycle and expressed as a percentage of the total observation time for that pair and for that period. The average percent time spent in each context was calculated for 7 to 13 pairs (Table 1).

Intraspecific non-mate encounters involving chases, supplants, grappling or an exchange of high-intensity vocal and optical displays or interspecific encounters involving supplants, chases, and alarm or mobbing calls were noted (Howes-Jones 1982).

Results

Arrival and Departure

The mean date of first sighting of males on territory was 10 May (n = 26 males). That date differed by one day from the mean arrival date in Hamilton of 9 May (n = 27 years, based on G. North, unpublished field notes). Of 20 pairs for which first arrival on territory was established for both birds, the male and female were together when first seen on 13 occasions; in five cases the female appeared one day after the male, in one case three days after, and in one case four days later.

Because most Warbling Vireos abandoned their territories after fledging, detailed observations were not made in August; however, all birds appeared to have left the study area by late August. The average of the latest dates for Warbling Vireos in Hamilton was 7 September (n = 26 years, G. North, unpublished field notes).

Pre-nest-building period and nest-site selection

Potential mates formed associations readily. On the first day or two of the period, mates appeared apprehensive on close approach to one another, showed mild aggression and vocalized constantly. Gradually, over the next several days, mates readily approached one another without apparent fear and vocalized less often and with low intensity contact calls (Howes-Jones 1982). During this period, pairs spent most of their time (80%, Table 1) together, usually foraging.

TABLE 1. Percent time spent by Warbling Vireos in eight contexts during the nesting cycle. Sample size represents numbers of individuals or pairs and in brackets the total amount of time in minutes for all individuals. The sample sizes (min) for individuals are similar. Where there is no sample size, values are estimates.

Context		Pre-nest-building period	Nest-building period	Incubation period	Nestling period
Male-alone-distant	n	7 (1245)	7 (1538)	7 (3687)	7 (3416)
	mean ± s.e.	19.6 ± 3.7	55.5 ± 5.9	39.6 ± 5.7	59.0 ± 6.0
	range	3.6–34.4	28.7–73.5	14.7–58.9	29.5–79.6
Male-alone-near-the-nest		—	7 (1538)	7 (3687)	7 (3416)
			8.6 ± 3.3	1.3 ± 0.5	14.9 ± 2.4
			2.6–29.7	0–3.7	2.6–21.4
Male-on-the-nest		—	—	13 (11261)	9 (6388)
				36.6 ± 3.6	14.9 ± 1.5
				19.1–52.8	7.3–21.5
Male-female-near-the-nest		—	7 (1538)	7 (3687)	7 (3416)
			9.1 ± 1.4	20.9 ± 6.0	11.7 ± 3.4
			1.8–11.9	6.4–53.0	4.0–29.1
Male-female-distant		7 (1245)	7 (1538)	7 (3687)	7 (3416)
		80.4 ± 3.7	26.9 ± 4.3	0.5 ± 0.5	0.8 ± 0.5
		65.6–96.4	13.2–49.7	0–3.7	0–4.2
Female-alone-near-the-nest		—	15	5	20
Female-alone-distant		7 (1245)			
		19.6 ± 3.7	40	35	45
		3.6–34.4			
Female-on-the-nest		—	10 (5500)	13 (11621)	9 (6388)
			7.8 ± 0.5	55.9 ± 1.8	23.5 ± 2.4
			4.7–11.0	44.2–64.5	15.1–39.1

The female tended to follow the male whenever he flew. Towards the end of the period, mates spent less time together; the female tended to move independently of the male, and were observed inspecting potential nest-sites at this time. When alone, males patrolled the boundaries of their territory and sang continually. The period averaged seven days in duration (n = 14 periods).

Only females appeared to select the nest-site. One female placed the first pieces of nesting material in forked branches in trees when alone. On three occasions and prior to any known nest construction, I saw lone females in flight with nesting material. Another female placed the first bit of nesting material when accompanied by the male; however, on subsequent visits, only the female returned to the nest-site.

Nest-building period

Nest-building in Warbling Vireos was exclusively a female activity. Of 1060 nest-building trips, only five may have involved a male carrying nesting material. Sutton (1949) observed males gathering nest material, but at nests I observed, males either deposited the material or flew away with it. Males were never observed weaving material in the manner of the female.

During the nest-building period, most of the female's time was associated with nest-related activities. Of the time spent by females building the nest, 8.0 ± 0.9% (n = 13 periods, 10 females, range = 3.7% to 13.2%) was spent weaving nesting material and 7.8% (n = 10, Table 1) was spent sitting on or molding the nest. Other than on trips to and from the nest, females seldom remained near the nest while building. Females spent about two-thirds of their time away from the nest (< 10 m), with searching for nesting material appearing to preoccupy most of that time. Females foraged outside the males territory and stole nest material from other nests. I observed resident Warbling Vireos attacking non-resident females (six occasions) or pairs (six occasions) which were either near or flying towards the resident's nest or which were at the nest and taking material.

Six of 13 females completed the first nest they started; three birds each began and abandoned one nest, and completed the second; three birds each began two nests but completed only the third, and one bird began three nests before completing the fourth. Nests which were abandoned were usually worked on for one to four days. One female renested when the previous nest was destroyed. Two nests were probably abandoned owing to the presence of Brown-headed Cowbird (*Molothrus ater*) eggs. The remaining nests were deserted for unknown reasons.

When a nest was started, a female may place nesting material in several locations before beginning to build at one location. When construction on a new nest was started, work usually stopped on the old nest. In only two renests were females observed to work on two nests for more than one day. Of 12 renesting attempts, only in two were females (different individuals) observed to dismantle the old nest and use its material to build the new nest. Renests were usually at some distance (32.8 ± 5.9 m, n = 18) from previous nests. The only exception was the third nest of a female (#22) which was built 30 cm from a partially-completed second nest. Work continued on both nests for four days before the second nest was abandoned. Once during the incubation period, the male (#22) was seen sitting in the second nest while the female was incubating in the third nest.

First nest actually completed took 7.2 ± 0.3 days (n = 17); whereas second, third and fourth nests averaged significantly less (6.0 ± 0.3 days, n = 8; $t = 3.047$, $p < 0.01$). When the first nest had been completed, females spent one or two days foraging near the nest or sitting for brief periods on the nest. Those apparent rest days were usually eliminated on subsequent nesting attempts.

During the nest-building period, male's time was spent in three contexts: (1) patrolling the territory and singing (55.5%, Table 1); (2) accompanying the female to and from the nest and while she foraged for nesting material (36.0%); and (3) alone, near the nest, and singing (8.6%). During the first day or two of the first nesting attempt males mainly patrolled their territories. After the second and third days males spent time accompanying the female or near the nest. When renesting, males usually accompanied the females from the first day. Buck (1896), Rust (1920) and Sutton (1949) have reported male Warbling Vireos accompanying their females during the nest-building period.

Almost all mating behaviour (96% of attempted copulations, n = 50) was observed during the relatively short intervals (9.1%, Table 1) when both mates were within 10 m of the nest. Mating activity peaked (on the average) on the fourth day, then decreased rapidly to near cessation by the onset of incubation. On one occasion I observed an attempt at cuckoldry. A non-resident male (sang in flight) attempted copulation with a resident female when she landed at her nest. The male then flew to a neighbouring territory, while the resident male sang at the other end of his territory.

Incubation period

Male and female Warbling Vireos shared incubation duties, but females incubated a significantly greater proportion of time than males (55.9% to 36.6%; $t = 5.910$, $p < 0.001$). Males started to incubate on the same day or up to three days after the

female. Males and females incubated for periods averaging 9.3 min and 12.3 min (n = 10, 211 visits), respectively. As most observation periods were limited to 60 min, the above values may be biased towards shorter periods. Several females occasionally sat on the nest for periods greater than 60 min.

When not incubating, neither adult remained near the nest, unless the male had a favoured song perch nearby. The latter condition accounted for the wide range among individuals (6.4% to 53.0%) for the context male-female-near-the-nest (Table 1). Generally, males spent most of their time singing and patrolling their territories. Exchanges of position on the nest by mates were well co-ordinated and difficult to detect. The incoming bird usually vocalized; the bird at the nest flew off and the incoming bird flew to the nest. All male Warbling Vireos (n = 13) sang while sitting on the nest. That behaviour seems characteristic of the species (Miller 1902; Rust 1920; Sutton 1949; Bent 1950; Salt 1973).

Nestling period

Both sexes, and in particular the female, brooded until the young started to fledge (Figure 1). Brooding by both sexes gradually waned during the period. Females brooded a significantly greater proportion of time than males (23.5% to 14.9%, n = 9; approx. $t = 2.885$, $p < 0.05$). As measured from first observed feeding of the young, the nestling period averaged 12 days (n = 11 periods, also Rust 1920) in length.

The apparent tendency for mates to maintain vocal contact which was evident prior to the nestling period declined noticeably thereafter. Overall, males spent most of their time (59.0%, Table 1) alone and at a distance from the nest and sang infrequently. However, males and especially females spent increasingly more time near the nest as the period progressed. When feeding, one adult generally waited for an approaching bird to vocalize nearby, then the bird at or near the nest immediately flew away, thus ensuring that one bird was almost always near the nest. Similar behaviour has been observed in other vireos and is regarded as a means of maximizing efficiency of care of young by adults and at the same time minimizing chances of nesting mortality due to predation (J. C. Barlow, personal communication). When sexes could be distinguished, the female averaged a greater number of feeding visits than the male (5.5 visits/h to 3.8 visits/h, n = 9 individuals, 101.4 h).

Fledgling period

On the day of fledging, the young seldom ventured more than 10 m from the nest. On the second and third days, fledglings were generally 30 m to 100 m from the nest. Rust (1920) found fledglings 65 m from the nest two days after fledging. From approximately

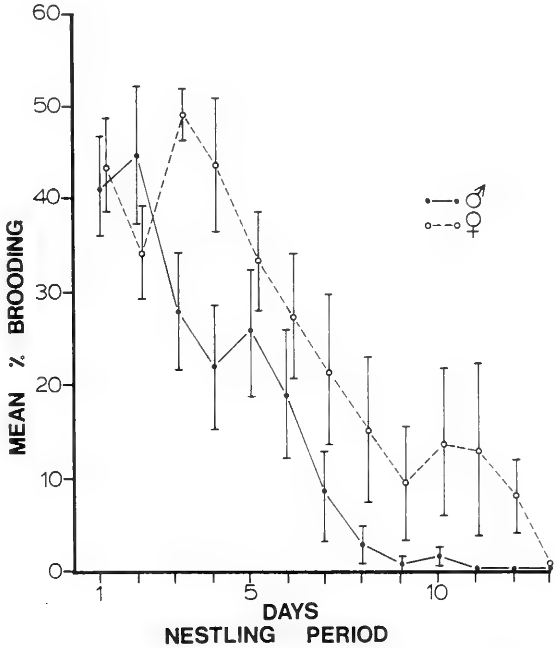

FIGURE 1. Percent time spent brooding by Warbling Vireos on each day of the nestling period. Means and standard errors are from sample sizes from eight pairs for the first six days, seven pairs for days 7 to 10, six pairs for day 11 and four pairs for days 12 and 13.

three days prior to until three days after first fledging, the young vocalized extensively and could easily be located (see Howes-Jones, in press). By the fourth or fifth day after fledging the young were relatively silent. At that time the young became widely dispersed, often outside the territory.

During the first few days of the fledgling period, the adults remained near the young. Both parents fed the young. If there were one or two fledglings, the female appeared to do most of the feeding. By one week after fledging, most observations were of single birds, indicating mates had become independent of one another.

Interactions

During 535 h of observation, 63 intraspecific nonmate encounters were documented (see Methods). Most interactions appeared associated with territorial defence and involved males. Circle-chasing and physical contact between interactants was infrequent. Primarily territorial defence involved the exchange of songs. During the pre-nest-building period, encounters were most frequent, averaging 0.49 /h (n = 51.6). The rate dropped sharply to 0.20 /h (n = 122.1 h) during the nest-building period and largely ceased thereafter.

Over the same observation period (above), 279 interspecific encounters were documented. Almost all interspecific encounters occurred near the nest (within 10 m) and were associated with nest defence. Without exception, any bird or mammal which approached the nest was mobbed or attacked. Interspecific encounters were most frequent during the nest-building period, averaging 1.0 /h (n = 122.1 h); decreased sharply during the incubation period (0.35/h, n = 206.3 h), then increased in the nestling and early fledgling periods (0.54/h, n = 121.3 h; 0.49/h, n = 28.7 h).

Discussion

Among the three members of the subgenus *Vireoslyva* nesting in Ontario, the habits and behaviour of the Warbling Vireo are more similar to those of the Philadelphia Vireo (*V. philadelphicus*) than of the Red-eyed Vireo (*V. olivaceus*). Both Warbling and Philadelphia Vireos pair readily, show low levels of mate-oriented aggression, tend to maintain constant visual and vocal contact between mates, have few but intense territorial interactions, have a relatively strong pair bond and move in unison to and from the nest (Sutton 1949; Bent 1950; Rice 1974; Barlow and Rice 1977; see the latter for detailed comparisons). It has been argued by Barlow and Rice (1977) that such behaviours are related to selection pressures due to shared incubation. The selection for a behaviour at one stage of the cycle (i.e. shared incubation) has influenced the expression of behaviours at other stages of the nesting cycle. The requirements of mutual attentiveness to the nest during the incubation period reduce the opportunities for interaction between mates which necessitates a strong pair bond being established.

In the Warbling Vireo, the high proportion of time mates spend together (80%) during the pre-nest-building period establishes familiarity which is likely necessary for the formation of a secure pair bond (see Erickson 1973; Marler 1976; Silcox and Evans 1982). The developing relationship between mates is indicated by changes in vocal behaviour, reduced aggressiveness and by the gradual acclimation by mates to the other's proximity. Those changes in behaviour appear to be prerequisites to nest-site search and selection.

In the Philadelphia Vireo the competing demands of the pair bond appear to reduce the time available for male-male territorial interactions which tend to be few in number but intense (Barlow and Rice 1977). The same appears to apply in the Warbling Vireo.

During the nest-building period, male Warbling Vireos spent 36% of their time apparently guarding the female (both near and away from the nest). Guarding may be defined as "the close following of females by their male partners shortly before and during the laying period" (Birkhead 1982). To a lesser extent, male Warbling Vireos also appear to guard the nest. Males spent 17.7% of their time near the nest (either alone or with the female). Apparent guarding of females by males has been observed in Philadelphia and Red-eyed Vireos (Sutton 1949; Lawrence 1953; Barlow and Rice 1977) and in numerous other monogamous species (Birkhead 1982). Several factors may contribute to the selection for guarding in Warbling Vireos.

Females show most courtship behaviour and appear most receptive to copulatory behaviour in the vicinity of the nest. By being near the nest or accompanying the female, the male ensures that he is with the female when she is most receptive to copulation.

Birkhead (1979, 1982) has argued that guarding is the most convincing evidence of cuckoldry avoidance in birds. Stolen copulations by strange males have been documented in many monogamous species (Bray et al. 1975; Gladstone 1979; Burns et al. 1980; Birkhead 1979, 1982). To maximize the chances of successful fertilization by a male, guarding should be most prevalent from three to four days before egglaying (Birkhead 1982). Male attentiveness is greatest among Warbling Vireos at that time; however, selective factors other than potential cuckoldry may also be important. In three field seasons only one apparent attempted stolen copulation by a strange male was recorded.

Nests of Warbling Vireos are subject to numerous incursions by passerines attempting to steal nest material. Aggression shown by Warbling Vireos towards any interloper near the nest is greatest in terms of number and intensity of attacks during the nest-building period. The greater number of encounters at that time may be due to the increased number of incursions, as other species are also nest-building and searching for nesting material; however, the heightened intensity of attacks suggests a selective response to the threat posed by other birds stealing nesting material, or by Cowbirds or predators (see Curio 1975). The increased aggressiveness shown by adult Warbling Vireos to interlopers near the young or nest at the time of fledging suggests that the behaviour is a selective response to the increased susceptibility of the young to predation (Curio 1975).

The habit of abandoning nests early in the nest-building process has been observed in other vireos (Bent 1950; Southern 1958; Barlow 1962; James 1973; Rice 1974). In those studies aborted nests were attributed to disturbances caused by humans, predators, Cowbirds, territorial conflict, and weather. The facts that renests of Warbling Vireos were on the average far apart and that females used nesting material from

previous nests infrequently, suggest that birds disassociated themselves from the old nest-site, perhaps reflecting some prior disturbance. However, the disturbance hypothesis does not explain the close nests of one female (#22). Its presence suggest that switches to other nest-sites may involve factors other than disturbance. The decision to build elsewhere may simply be based on the suitability of the site after a longer period of search.

Acknowledgments

I am grateful to R. D. James and J. C. Barlow for their comments and suggestions on this manuscript and to G. North for the use of his field records. Funds in support of this work, which in part encompassed doctoral research at the University of Toronto by Howes-Jones, was provided by grant A-3472 to J. C. Barlow from the National Science and Engineering Research Council of Canada.

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Received 19 December 1983
Accepted 5 September 1984

Distribution of Mayfly Nymphs (Insecta: Ephemeroptera) in Some Streams of Eastern Canada as Related to Stream pH

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Numbers of ephemeropteran genera in riffles of 20 streams of Nova Scotia and New Brunswick, Canada, were greater in streams of high pH than in streams of low pH. More species of Ephemerellidae occurred in samples from streams of high pH than from streams of medium or low pH.

Key Words: Ephemeroptera, pH, Nova Scotia, New Brunswick

The diversity of benthic invertebrates as related to stream and lake pH has been surveyed in Norway (Leivstad et al. 1976; Økland 1980; Raddum 1980), Swede (Friberg et al. 1980) and England (Sutcliffe and Carrick 1973). Mayflies are among the more sensitive orders of benthic insects with diversity decreasing in more acidic streams.

Streams in southwestern Nova Scotia are acidic with pH levels ranging from 4.4 to 6.0. Acid precipitation has been proposed as one of the factors contributing to this acidity. The relationships among precipitation acidity, regional geology, and stream chemistry have been discussed by Watt et al. (1983), Thompson et al. (1980), Kerekes et al. (1982) and Farmer et al. (1980). Streams in the southwest corner of Nova Scotia arising on a bedrock of metamorphosed slates and quartzites (meguma formation) are most acidic. Widespread bogs and heaths also contribute to the acidity and most streams are highly colored.

In view of the acidification of many streams in southwestern Nova Scotia, 18 Nova Scotian streams were sampled for Ephemeroptera. For comparison, two streams in southwestern New Brunswick, arising mainly on granitic bedrock, were also sampled (Figure 1).

Methods

Benthic invertebrates were sampled with a Surber sampler (square pore mesh of 450 μm on a side) that sampled 0.093 m^2 of substrate. Midstream riffle areas below pools were sampled. Mean sampling depths ranged from 16 to 38 cm (range for individual sites was 12–70 cm). Corresponding values for water velocities (measured 2.5 cm above the substrate with an Ott® propeller-type flowmeter) were 19 to 56 cm s^{-1} and 11 to 119 cm s^{-1}. The substrate consisted of fine to coarse gravel with occasional larger stones. Larger surface stones were scrubbed by hand, then the gravel was stirred vigorously for one minute with a garden claw-type cultivator. Samples were preserved in 70% ethanol and manually sorted under the low power of a stereoscopic microscope. Most streams were sampled both in early June and late August, 1981, with 6 to 10 samples taken per stream. Ephemeropteran nymphs were identified to genus, using keys in Edmunds et al. (1976). Mature *Stenonema* nymphs were identified to species from Bednarik and McCafferty (1979), and mature Ephemerellidae to species from Burks (1953).

Stream order varied from 2 to 5 with most being 3rd or 4th order. The pH levels used in analyses were mean summer levels derived from measurements taken during sampling, from unpublished data of Farmer (personal communication) and from Watt et al. (1983) and Farmer et al. (1980). They represent mean maximal pH levels with lower pH levels prevailing during fall and spring freshets. For analysis, streams were grouped into three categories: "High" pH ($\geqslant$ 5.5), "Medium" pH (4.7-5.4), and "Low" pH ($\leqslant$ 4.7).

Results

Nine genera were identified in the study (Table 1). Genera that were sampled less frequently or not at all in streams of low pH are *Epeorus, Tricorythodes, Isonychia, Baetis* and *Heptagenia*. The late-instar *Paraleptophlebia* nymphs collected in June were not present in streams of mean pH < 4.8, with few specimens in streams of mean pH < 5.9. Conversely, early instar nymphs collected in August were common in streams with pH as low as 4.7. The differences in number of genera sampled per stream could not be attributed to stream order as orders 2 to 4 were represented over the entire pH range (only one order-5 stream was sampled), nor could geographical considerations explain the differences in number of genera. The streams of lowest pH were bounded both in the east and northwest by streams of higher pH. No *Baetis*

TABLE 1. Ephemeropteran genera present in the various streams. Streams have been grouped into three categories: "High" pH ($\geqslant$ 5.5), "Medium" pH (4.7-5.4), and "Low" pH (< 4.7). Figures outside parentheses are numbers of each genus collected per sample. First figure in parentheses is the proportion of samples containing a given genus; the second figure is the number of streams in the pH category in which the genus was found.

Stream pH	*Stenonema*	*Epeorus*	*Heptagenia*	*Paraleptophlebia*	*Habrophlebia*	*Ephemerella*	*Tricorythodes*	*Isonychia*	*Baetis*	No. of Samples
"High" (8 streams)	4.6 (0.59,8)	1.1 (0.28,5)	0.3 (0.06,4)	1.4 (0.42,8)	0.06 (0.04,3)	4.1 (0.68,7)	0.1 (0.10,5)	0.04 (0.04,4)	1.6 (0.47,8)	134
"Medium" (7)	7.1 (0.80,7)	0.08 (0.05,3)	0.1 (0.35,7)	1.4 (0.35,7)	0 (0 ,0)	5.3 (0.48,7)	0 (0 ,0)	0 (0 ,0)	0.3 (0.09,3)	91
"Low" (5)	1.5 (0.42,5)	0	0 (0 ,0)	0.01 (0.01,1)	0.07 (0.01,1)	1.1 (0.25,4)	0 (0 ,0)	0 (0 ,0)	0.04 (0.03,1)	69

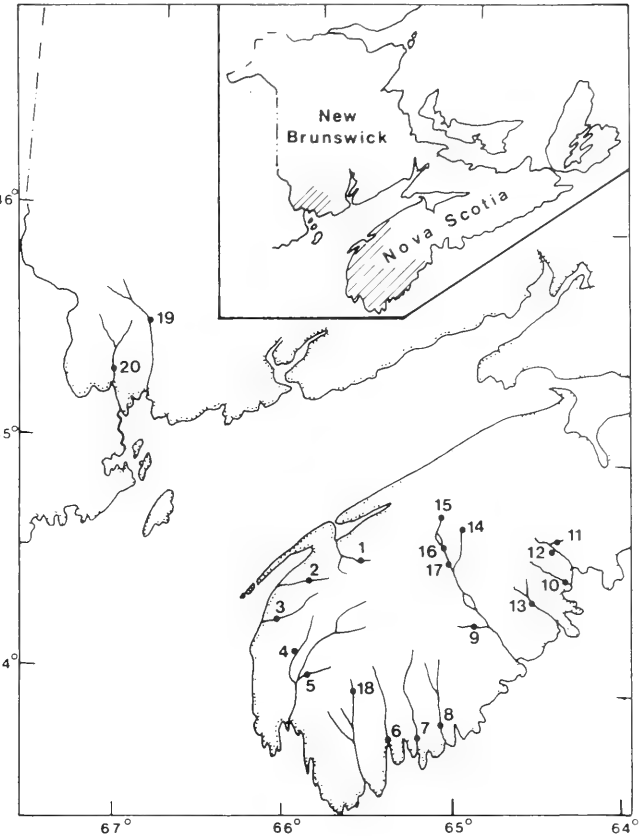

FIGURE 1. Map of Maritime provinces showing location of streams sampled; 1: Bear River, 2: Meteghan River, 3: Salmon River, 4: Carleton River, 5: Tusket River, 6: Roseway River, 7: Jordan River, 8: Sable River, 9: 15-Mile Brook, 10: Martins River, 11: Mill Brook, 12: Gold River, 13: La Have River, 14: Pleasant River, 15: Halfway Brook, 16: Westfield River, 17: Medway River, 18: Hemlock Creek, 19: Digdequash River, 20: Waweig River.

specimens were collected in June in streams of pH < 4.8, and only in one of pH between 4.8 and 5.5. Densities of *Baetis* nymphs increase throughout the summer (Peterson, unpublished data); thus more were taken in the August samples. They were collected then only occasionally in streams of pH < 5, but consistently in streams of higher pH.

Stenonema luteum and *S. modestum* were present in most streams of all pH categories (Table 2), and only one specimen of *S. femoratum* was identified. Ten species of Ephemerellidae were identified from streams of "high" pH, five from streams of "medium" pH and four from streams of "low" pH. *Drunella lata* and *D. cornuta* were common at "high" pH, but were not collected at "low" pH. In addition, five species

TABLE 2. Ephemeropteran species present in streams of "High" (≥ 5.5), "Medium" (4.7-5.4), and "Low" pH (≤ 4.7). Figures outside parentheses are numbers of each species collected per sample. First figure in parentheses is the proportion of samples containing a given species; the second figure is the number of streams in the pH category in which the species was found.

	Stream pH		
	"High" (8 streams)	"Medium" (7)	"Low" (5)
Stenonema luteun	1.6 (0.27,7)	1.8 (0.29,4)	0.5 (0.12,3)
modestum	0.6 (0.26,5)	1.8 (0.50,4)	1.8 (0.48,4)
vicarium	0.01 (0.01,1)	0	0.02 (0.02,1)
femoratum	0.01 (0.01,1)	0	0
Drunella tuberculata	0	0.3 (0.07,1)	0.02 (0.02,1)
lata	1.5 (0.25,3)	0	0
cornuta	1.9 (0.29,6)	0	0
walkeri	0.03 (0.03,2)	0.03 (0.02,1)	0.14 (0.08,3)
Eurylophella temporalis	0	0	0.02 (0.02,1)
versimilis	0.03 (0.01,1)	0.03 (0.02,1)	0
aestiva	0	0.02 (0.02,1)	0
bicolour	0.04 (0.03,1)	0	0
Serratella serrata	0.13 (0.03,1)	0	0
deficiens	0.08 (0.04,2)	0	0
Ephemerella dorothea	0.04 (0.03,1)	0	0
excrucians	0.04 (0.03,1)	0	0
invaria/rotunda	1.6 (0.38,7)	2.7 (0.33,4)	1.1 (0.23,5)
No. of species			
Stenonema	4	2	3
Ephemerellidae	10	5	4

(e.g. *Serratella serrata*) were sampled occasionally from "high" pH streams, but were not encountered in streams of "medium" or "low" pH.

Mean depths and velocities among streams in the three pH categories did not differ significantly (ANOVA). Mean velocities in streams of "low", "medium" and "high" pH in June were 44, 49, and 46 cm s^{-1}, respectively. Mean depths was 30, 30, and 28 cm, respectively. Corresponding values in August were 46, 46, and 47 cm s^{-1}, respectively, for velocities, and 31, 28, and 29 cm, respectively, for depths.

Discussion

The results indicate that some mayfly genera (e.g. *Baetis, Epeorus*) may be less frequent in streams of lower pH. The influence of stream pH on numbers of mayfly taxa confirms similar findings in Norwegian studies (Leivested et al. 1976). The Norwegian streams had much lower dissolved organic carbon content as their surveys concentrated on clear water lakes, so that heavy-metal toxicity may be a significant factor at pH levels ≤ 5.5. With the highly colored Nova Scotia waters, metal toxicity should not be a factor as metals would be chelated by the humic materials (Clair and Komadina 1984).

Baetis is a major component of the drift in streams and consequently an important food source for juvenile salmonids which are predominantly drift feeders (Elliot 1963). Sutcliffe and Carrick (1973) found *Baetis* spp. to be absent from streams with pH < 5.3 in the English lake district. We found only occasional *Baetis* specimens in streams with pH < 5.4 in Nova Scotia. The paucity of *Baetis* in streams of pH 5.0-5.4 may impose some constraints on Atlantic salmon production in these streams. Sutcliffe and Carrick (1973) suggested that adult female *Baetis* avoided laying eggs in the more acidic streams. Friberg et al. (1980), in a study of benthic invertebrates of Swedish streams, found the absence of Ephemeroptera and elmid beetles the most noticeable difference of acid streams (4.3-5.9). Similarly, Harriman and Morrison (1980) found that only one species of mayfly (*Siphlonurus*) was present in an acid stream (4.4).

This study indicates that some common *Drunella* species (*lata* and *cornuta*) may also be absent from streams of low pH.

Acknowledgments

M. J. Dadswell and G. L. Lacroix reviewed the manuscript. F. Cunningham prepared the figures. B. Garnett typed the manuscript and R. Garnett edited it. D. Martin-Robichaud helped identify the mayfly species. The Stroud Water Research Institute (D. Rebuck) kindly confirmed identification of some *Stenonema* and Ephemerellidae species.

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Received 2 February 1984
Accepted 15 November 1984

High Density of Heather Voles, *Phenacomys intermedius*, in Jack Pine, *Pinus banksiana*, Forests in Ontario

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Naylor, Brian J., James F. Bendell, and Stephen Spires. 1985. High density of Heather Voles, *Phenacomys intermedius*, in Jack Pine, *Pinus banksiana*, forests in Ontario. Canadian Field-Naturalist 99(4): 494‡497.

One-hundred and forty-six Heather Voles (*Phenacomys intermedius*) were collected in eight Jack Pine (*Pinus banksiana*) forests in northeastern Ontario in 5398 snap trap nights and 12 579 pitfall nights. Parallel lines of snap traps were the most efficient trapping method. Pitfalls captured a significantly greater proportion of young voles. Low densities and high proportion of juveniles suggested that disturbed and mixed forests acted as dispersal sinks. Monocultures exhibited higher densities of the Heather Vole than previously reported. These forests may provide optimum habitat because they concentrate resources preferred by Heather Voles. Dense, relatively continuous understories of Ericaceous shrubs may provide food, protection from predators and conspecifics, or favourable microclimates.

Key Words: Heather Vole, *Phenacomys intermedius*, Jack Pine, *Pinus banksiana*, monocultures, Sheep Laurel, *Kalmia angustifolia*.

The range of the Heather Vole (*Phenacomys intermedius*) extends across Canada and southward along the Rocky Mountains to northern New Mexico (Banfield 1974). Despite this wide distribution, it is considered rare (Banfield 1974). The Heather Vole is reported from deciduous, mixed, and coniferous forests (Saunders 1927; Negus 1950; Edwards 1955; Foster 1961; Soper 1961a,b; Krebs and Wingate 1976; Nagorsen and Peterson 1981; Innes and Millar 1982; Nagorsen 1982; Martell 1983) and open habitats including sagebrush flats, boreal clearcuts, alpine meadows, and willow thickets (Saunders 1927; Manning 1948; Negus 1950; Foster 1961; Edwards 1963; Krebs and Wingate 1976; Martell and Radvanyi 1977; Innes and Millar 1982; Martell 1983). Observed densities in these studies range from 0.02 to 3.60 captures per 100 snap trap nights. We report on the occurrence of the Heather Vole in Jack Pine (*Pinus banksiana*) forests in northeastern Ontario, and draw attention to high densities (1.41 to 9.59 captures per 100 snap trap nights) found in monocultures. We also suggest factors that may be responsible for this high density.

Study Areas and Methods

The study area was located in the Missinaibi-Cabonga section of the boreal forest region (Rowe 1972), on an extensive sand flat 20 km south of Gogama, Ontario (47° 30′N, 81° 40′W). We sampled rodents and shrews in eight Jack Pine forests ranging in age from 1 to 60 years, and in size from 25 to 100 ha (Naylor and Bendell 1983).

Three pure stands (100% Jack Pine by basal area) were situated on deep, fine to coarse sandy soils. Three mixed stands, located on loamier sands of varying depth, contained Jack Pine (64–73% by basal area), White Birch (*Betula papyrifera*), Trembling Aspen (*Populus tremuloides*), Black Spruce (*Picea mariana*), White Spruce (*P. glauca*), and Balsam Fir (*Abies balsamea*).

The understory of pure stands consisted almost exclusively of a continuous low shrub layer of Blueberry (*Vaccinium angustifolium* and *V. myrtilloides*), Sheep Laurel (*Kalmia angustifolia*), and Sweetfern (*Comptonia peregrina*). In contrast, the understory of mixed stands contained several patchy but distinct strata. These included: a tall shrub layer of Green Alder (*Alnus crispa*), Beaked Hazel (*Corylus cornuta*), and Pin Cherry (*Prunus pensylvanica*); a low shrub layer of Bush Honeysuckle (*Diervilla lonicera*), Blueberry (*V. myrtilloides*), and Wild Sarsaparilla (*Aralia nudicaulis*); and a herb layer containing Bunchberry (*Cornus canadensis*), Clintonia (*Clintonia borealis*), and Canada Mayflower (*Maianthemum canadense*).

The ground layer in pure stands consisted of a mixture of Jack Pine needles, Ericaceous shrub litter, and mosses of the genera *Pleurozium* and *Dicranum*. Conifer needles, moss, and broad-leaved litter from deciduous trees, shrubs, and herbs comprised the ground layer in mixed stands.

Recently disturbed forests included a two-year-old scarified clearcut of a pure Jack Pine forest and a one-year-old burn of a mixed Jack Pine forest. Vegetation on these sites generally reflected the understory composition of the undisturbed forests. However, species typical of disturbance such as Fireweed (*Epilobium angustifoluim*), Bicknell's Cranesbill (*Geranium bicknellii*), and various grasses and sedges were also present.

Within each forest, overstory composition (by basal area) was determined using a 20 point plotless timber cruise (Grosenbaugh 1952). The abundance (percent cover) of understory and ground layer species was visually estimated using 20–4^2 m quadrats.

Small mammal populations were sampled simultaneously within each forest using a combination of 10 cm Victor snap traps baited with peanut butter and oatmeal and plastic pitfall traps (15 cm dia. × 18 cm deep) containing 5 cm of a 30% ethyl alcohol preservative. Each forest contained four parallel snap trap lines, 50 m apart. Each line consisted of 20 stations at 15 m intervals with three traps per station. One line was run for 72 h every other week. Wherever possible snap traps were positioned in the expected path of small mammals (eg. entrance to holes, runways, and under logs). Traps were visited each morning during the trapping period and re-baited when necessary.

Twenty pitfall traps were located randomly along the snap trap lines. Pitfall traps captured small mammals continuously during the study period and were emptied weekly.

A total of 5398 snap trap nights (STN) and 12579 pitfall nights (PFN) was accumulated during the eight weeks of sampling in June and July 1982. Number of traps did not limit the number of captures because: 1) less than 20% of all snap traps were set off any night; 2) rarely were all three snap traps at one station set off; and 3) pitfall traps continued to capture small mammals even when they contained dead shrews or voles.

Statistical analyses included chi-square tests for differences between proportions (Sokal and Rohlf 1969) and multiple linear regression (Statistical Analysis System, Ray 1982). Statistical significance was established at the 5% level.

Results and Discussion

A total of 146 Heather Voles was captured (Table 1). In contrast to observations by Edwards (1952), snap traps were more efficient than pitfalls (2.09 Heather Voles/100 STN vs 0.41 Heather Voles/100 PFN). Orientation of voles caught in snap traps suggested that most captures resulted from animals crossing traps, rather than from taking the bait. Thus, our results support Foster's (1961) contention that the effectiveness of snap traps in capturing Heather Voles is largely dependent upon trap placement. Pitfall traps yielded a significantly higher proportion of young (juvenile) voles (individuals less than 18g) than did snap traps ($\chi^2 = 9.455$, $P < 0.05$). Thus, type of trap may influence age structure of captures. Sex ratio of captures was similar in both traps ($\chi^2 = 0.001$, $P > 0.05$) and averaged 1.4 females per male. Saunders (1927) and Innes and Millar (1982) also reported collecting more females than males. Innes and Millar (1982) suggested that this indicated unequal trappability of the sexes.

Most Heather Voles were caught in pure Jack Pine forests (Table 1). Although results are not strictly comparable, these monocultures exhibit considerably higher densities of the Heather Vole (mean 4.40/100 STN) than reported from other upland coniferous forests in which this vole has been found (range 0.50–1.70/100 STN) (Nagorsen and Peterson 1981; Innes and Millar 1982; Martell 1983). Captures in our mixed forests (mean 0.10/100 STN) are comparable to those observed in mixed forests in the above studies (range 0.02–0.33/100 STN). However, Heather Vole densities in our recently disturbed forests (mean 0.58/100 STN) are lower than reported from clearcuts in other coniferous forest types (range 1.3–3.6/100 STN) (Martell and Radvanyi 1977; Martell 1983).

Population densities of the Heather Vole are thought to fluctuate (Foster 1961). Thus, our high densities in Jack Pine monocultures might represent unusually high peak populations. However, this is doubtful because Lattner (unpublished data) caught even higher densities in the young and medium-aged pure forests (0.39 and 2.86 captures/100 PFN, respectively) during invertebrate sampling in 1981 (Lattner 1982).

Vole age ratios (adult:juvenile) were not significantly different ($\chi^2 = 1.316$, $P > 0.05$) among ages of pure forests and averaged 1.9 juveniles captured per adult. Only 2 of 17 voles caught in disturbed and mixed forests were adults. This apparent higher proportion of juveniles could be an artifact of the trapping procedure. Population density might be so low in disturbed and mixed forests that our trapping intensity was insufficient to capture many adults. However, higher proportion of juveniles may reflect real differences in demographic parameters between populations in pure forests and disturbed and mixed forests. The most likely explanation for the low density and high proportion of juveniles in disturbed and mixed forests is that these forests act as dispersal sinks. Powell (1972) and Van Horne (1982) suggested that adult cricetids in optimal habitats may, through agonistic social interaction, force surplus juveniles into marginal habitats (niche displacement). Overwinter survival of these surplus juveniles may be low (Van Horne 1982), resulting in a paucity of adults in the habitat and an age ratio biased in favour of juveniles.

Foster (1961) also found a high density of Heather Voles in a Jack Pine monoculture in northern Quebec. We suggest that high density and relative abundance of adult Heather Voles in pure Jack Pine forests may be a function of the homogeneous nature of the habi-

TABLE 1. Captures of *Phenacomys intermedius* on eight Jack Pine study sites near Gogama, Ontario.

Site	Snap trap captures Adults	Snap trap captures Young	#/100STN	Pitfall captures Adults	Pitfall captures Young	#/100PFN
Recently disturbed						
Cut	2	4	0.86	0	4	0.26
Burn	0	2	0.30	0	2	0.13
Pure forests						
Young*	5	5	1.46	3	6	0.57
Medium	27	39	9.59	2	19	1.38
Old	6	9	2.14	2	6	0.49
Mixed forests						
Young	—	—	—	—	—	—
Medium	0	1	0.15	0	1	0.06
Old	0	1	0.15	0	1	0.00
Totals	40	61	2.09	7	38	0.41

*20, 40, and 60 years old respectively

tat. Homogeneous environments contain a low diversity of resources. However, resources present are often in great abundance and uniformly distributed. Root (1973) postulated that species adapted to use these concentrated resources could attain unusually high densities. A most striking habitat feature of our Jack Pine monocultures is the relatively continuous dense understory of Ericaeous shrubs. Cover of Sheep Laurel and Blueberry accounts for most of the variance observed in total captures of Heather Voles in the eight forests (multiple R-square: 0.9434, $P < 0.05$). The bark of Sheep Laurel and Blueberry is a major winter food of the Heather Vole (Foster 1961; Banfield 1974). Foliage and fruits of these species also represent important summer foods (Banfield 1974). Cover of Sheep Laurel alone, correlates more highly with Heather Vole abundance than any other single habitat feature (R-square: 0.9296, $P < 0.05$). We noted many caches of Sheep Laurel at the entrance to small mammal holes in the forest with highest population density. Thus, concentration of Sheep Laurel as a food resource may explain abundance of this vole in Jack Pine monocultures. This possibility is noteworthy, because Sheep Laurel is generally regarded as toxic to vertebrates (Hall et al. 1973) and is not eaten by boreal herbivores such as Moose, *Alces alces*, (Peterson 1955) and Spruce Grouse, *Dendragapus canadensis* (Lattner 1982). Although Blueberry plants were heavily defoliated by Leaf-rollers (Tortricidae and Olethreatidae), Loopers (Geometridae), and Noctruids (Noctuidae), contiguous stands of Sheep Laurel within these forests were relatively free of insect damage. This species is also relatively free of fungal infections (Hall et al. 1973). Furthermore, the litter of Sheep Laurel decomposes at a relatively slow rate (Damman 1971). Thus, Heather Voles may play an important role in recycling nutrients in Jack Pine-Sheep Laurel habitats.

The dense Ericaceous shrub layer may also provide shelter from a variety of mammalian and avian predators. Protection from predators may be especially important to Heather Voles because their unwary nature appears to make them easy prey (Foster 1961). The dense low shrub layer may also reduce mutual interference from conspecifics. Visual screening and spatial barriers may promote tolerance among individuals and higher population densities. Furthermore, ground level microclimate may be modified by the dense low shrub layer.

Pure Jack Pine forests, and monocultures in general, are usually regarded as rather sterile habitats for wildlife. However, high population densities of the Heather Vole (this study) and Spruce Grouse (Szuba and Bendell 1983) do occur in Jack Pine monocultures. Thus, resource concentration may permit some species to reach high density within these homogeneous environments. Hence, monocultures may provide unique opportunities to study species generally found in very low densities.

Acknowledgments

We are indebted to the Ontario Ministry of Natural Resources and the Natural Sciences and Engineering Research Council of Canada for financial support. K. J. Szuba and R. E. Wetzler provided valuable criticism and discussion. An anonymous referee made helpful comments.

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Received 25 January 1984
Accepted 14 September 1984

Four Violets New to the Saskatchewan Flora and Other Rare Violets of East-Central Saskatchewan

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Harms, Vernon L., Donald F. Hooper, and Les Baker. 1985. Four Violets new to the Saskatchewan flora and other rare violets of east-central Saskatchewan. Canadian Field-Naturalist 99(4): 498–502.

Four violet species: *Viola macloskeyi* spp. *pallens, V. incognita, V. sororia,* and *V. septentrionalis,* are reported from east-central Saskatchewan as new to the known flora of the province. A previous report of *V. blanda* in Saskatchewan is discounted. Additional collections resubstantiate the Saskatchewan occurrence of *V. pubescens* var. *leiocarpa,* and show the purportedly rare *V. selkirkii* to be a relatively frequent violet species in east-central Saskatchewan.

Key Words: Saskatchewan, violets, *Viola macloskeyi* spp. *pallens, V. incognita, V. sororia, V. septentrionalis, V. blanda, V. pubescens, V. selkirkii.*

During June 1983 and June 1984 while botanizing in the Pasquia and Porcupine Hills regions of east-central Saskatchewan, the authors discovered four species of violets new to the known flora of Saskatchewan. Additional collections have better substantiated the Saskatchewan occurrences of two other purportedly rare violet species. These provincial records, along with abbreviated collecting data, noteworthy characteristics and distributional notes, are cited below:

***Viola macloskeyi* Lloyd spp. *pallens* (Banks) M. S. Baker** [syn. = *V. pallens* (Banks) Brainerd]. **Sweet or Northern White Violet.** 7 km northwest of Chelan (26–T42–R11–W2); on hummocks in very wet, springy, marshy fen-pond; 13 June 1983, *Hooper & Baker no. 83-06-13-05;* 1 July 1982, *Leila Hooper s.n.* (capsular sample); 3 June 1984, *Baker & Harms no. 32362.* Brockelbank Hill, in Porcupine Hills, south of fire-tower road, 1 km west of Woody Lake Road, 22½ km south of Armit (26–T42–R31–W1); on hummocks in wet sedge meadow bordering lake; 8 June 1984, *Harms, Hooper & Baker no. 32548.*

This species is characterized by (1) scapes quite elongate; (2) leaves small (in ours less than 2 cm long and broad), glabrous above and becoming glabrate below, crenulate, and blunt-tipped; (3) petioles and scapes sparsely hirsutelous; (4) flowers small, less than 1 cm long; (5) capsules green and ellipsoid-cylindrical; (6) petals white with the lower three strongly purple-lined, the lateral ones beardless or somewhat bearded with an inconspicuous tuft of white hairs, and the upper two obovate; and (7) notably fragrant flowers. In its superficial appearance, as well as its very wet habitat, this species reminds us most of the white form of *V. palustris,* which is common in east-central Saskatchewan. It differs from the latter most noticeably by its smaller flowers, leaves generally smaller, three lower petals more strongly and elaborately purple-lined, and two lateral petals often somewhat bearded.

Previously *Viola macloskeyi* spp. *pallens* has been recorded (as *V. pallens*) westward in Manitoba to about 100° longitude (from the Brandon area north to Nueltin Lake) according to the distribution map in Porsild and Cody (1980). The latter also mapped this species across southern District of Keewatin and in District of Mackenzie at isolated stations north of Great Slave Lake and west of Great Bear Lake. Packer (1983) mapped *V. macloskeyi* spp. *pallens* at three sites in southwestern and central Alberta. Submerging this taxon completely under *V. macloskeyi,* Scoggan (1978) reported the combined species as essentially transcontinental except "not known from Saskatchewan". The Brockelbank Hill and Chelan records for *V. macloskeyi* subsp. *pallens* represent an approximately 200 km westward extension from its recorded Manitoba localities, but still leave a sizable apparent mid-continental gap of over 700 km between east-central Saskatchewan and central Alberta. This taxon is similar enough to, and in its western range reportedly intergrades with, the entire-leaved Pacific Coast *V. macloskeyi* s. str., so it would seem best treated as conspecific with it, separable at a subspecies level. But its merger with *V. blanda* Willd. by Boivin (1966, 1967) and some others does not appear warranted.

***Viola incognita* Brainerd. Large-leaved White-Violet.** Brockelbank Hill, in Porcupine Hills, at and just below the north brow of the summit along Woody Lake

Road, 22½ km south of Armit (25–T42–R31–W1); locally numerous in patches on mesic-moist, mostly shaded, mossy slopes bordering streamlets, under White Spruce and White Spruce-Balsam Poplar-White Birch-River Alder woods; 29 June 1983, *Harms, Hooper & Baker nos. 32133, 32157; Hooper & Baker no. 83-06-29-03;* 6–7 June 1984, *Harms & Baker nos. 32486, 32495, 32498.* North Slopes of Porcupine Hills, 10 km south of National Mills, Manitoba (34–T43–R29–W1), in moist shaded depression under aspen woods; 12 September 1983, *Baker & Hooper no. 83-09-12-05.* The latter collection, from only 18 km northeast of the Brockelbank Hill site, consisted of specimens in capsular stage appearing otherwise completely comparable to the flowering and fruiting specimens of the former.

Viola incognita is characterized by (1) soft white pubescence on the scapes, petioles and leaf undersurfaces, but leaves glabrous or nearly so above; (2) petals white, with the three lower ones strongly purple-veined and only the two lateral ones ± bearded; (3) leaves rugose-surfaced and acute-tipped, with widely open basal sinus, and margins scalloped-crenulate; (4) capsules ovoid and purple-blotched; (5) rootstocks short, becoming thick; (6) stolons frequent, often quite long, ± leafy; and (7) scapes subequal to often somewhat longer than the leaves. Another characteristic noted for *V. incognita,* but not apparent in most other acaulescent white violets of the region except some *V. renifolia,* was a distinct curving of the leaf lateral veins upward and inward toward the apex.

Viola incognita is another eastern species, previously reported only as far west in Canada as Quetico Provincial Park, about 200 km west of Thunder Bay, Ontario (Walsh 1980), and in adjacent United States west to northwestern Minnesota and northeastern-most North Dakota (McGregor et al. 1977). It was not reported from Manitoba by Scoggan (1957, 1978), Boivin (1966, 1967), or Looman and Best (1979). But Boivin (1966) omitted any reference to *V. incognita,* even in synonomy, for anywhere in Canada, and material belonging to this taxon keys out in his flora (Boivin 1967) to an unacceptably broad *V. blanda.*

The present record of *V. incognita* from Brockelbank Hill in the Porcupine Hills of east-central Saskatchewan, represents a significant northwestward extension of the species' known range by at least 650 km (perhaps over 1000 km), and thus was the most surprising of the four new violet discoveries in Saskatchewan. Our Porcupine Hills specimen-material, which is ample in terms of both good flowers and capsules, compares well to descriptions and examples of only this species, and the identification appears unequivocal. Our collection from south of National Mills would appear to represent the first Manitoba record of this species but needs better substantiation by flowering specimens. We would suggest however, that the bases for Scoggan's (1957) various reports of *V. blanda* in Manitoba be rechecked for some possible *V. incognita.*

Hudson (1976) reported, "with some uncertainty", the Woodland White Violet, *V. blanda,* as new for Saskatchewan, based on his 1974 collection (*J. H. Hudson no. 2924;* SASK) from the Porcupine Hills, 14.9 miles south of Armit. The voucher specimen for the latter has now been redetermined by us as *V. incognita,* so, at least for the present, *V. blanda* should be excluded from the Saskatchewan floral list. Hudson's collection site appears to have been about 1–1.5 km south of our own Brockelbank Hill collections of *V. incognita.*

***Viola sororia* Willd. Woolly Blue Violet.** 3–5 km west of Carragana (36–T41–R9–W2 and 1–T42–R9–W2); under moist aspen and aspen–balsam poplar–willow woods; 2 June 1983, Baker no. 83-06-02-06; 4 June 1983, *Hooper & Baker no. 83-06-04-01;* 2 June 1984, *Harms and Baker no. 32321.* 5.5 and 9 km south of Somme, 1½–5 km north of Piwei River (4 & 16–T41–R7–W2); under moist aspen woods; 2 June 1984; *Harms, Baker & Hooper 32300, 32350.*

This species is characterized by (1) leaves thickish, prominently crenate-toothed, abruptly acute, ± densely and equally villous-pubescent above and below; (2) scapes and petioles ± pubescent; (3) sepals distinctly fine-ciliate below the middle, the auricles broad, ± appressed; (4) capsules ovoid and purplish-mottled; (5) petals blue-violet, the two lateral ones densely white-bearded, the lower spurred one only sparsely if at all bearded, and the three lower petals with white purple-veined bases; and (6) cleistogamous capsules on short prostrate peduncles. Our specimens are all relatively small-leaved (< 3 cm broad and long) and not strongly pubescent.

Viola sororia is an Eastern North American species previously recorded west only to the Red River region in northwestern Minnesota and eastern South Dakota (McGregor et al. 1977), and to western Manitoba where it was recorded at Aweme south of Brandon, Fork River north of Dauphin (Scoggan 1957), and the Riding Mountain National Park (Cody 1983 ms. Checklist of Plants of the Riding Mountain National Park, Manitoba. 40 pp.), in addition to more eastern Manitoba reports from Portage-la-Prairie, Winnipeg, Roseisle, Victoria Beach, McCreary, Morden (Scoggan 1957), and the Whiteshell area near Pinawa (Dugle 1969). Scoggan (1978) suggested, however, that Manitoba records required confirmation. Accepting the validity of western Manitoba records,

the present record from Carragana, Saskatchewan, represents an approximately 200 km northwestward extension of the species' known range and so would not represent an unexpected discovery for Saskatchewan. Boivin's (1966, 1967) submergence, under an unacceptably broad *V. cucullata* Aiton, of *V. sororia,* together with *V. nephrophylla* Greene, and presumably *V. septentrionalis* Greene as well (which he omitted entirely for anywhere in Canada, even in synonomy), seems an excessive combination of taxa that appear to be adequately distinct in nature and readily enough distinguishable.

***Viola septentrionalis* Greene. Northern Blue Violet.** 3–5 km west of Carragana (31–T41–R8–W2, 36–T41–R9–W2 & 1–T42–R9–W2); under semi-open aspen and aspen–white spruce woods; 2 June 1984, *Harms & Baker nos. 32316, 32322.* 11 km northeast of Weekes (24–T42–R6–W2); open borders of white spruce–aspen woods; 2 June 1984, *Harms, Hooper & Baker no. 32304.*

Viola septentrionalis is another blue-flowered violet similar to *V. sororia.* It is characterized by (1) ± hirsutulous pubescent leaves, petioles and scapes, with leaf surfaces more densely pubescent below than above; (2) sepals long-ciliate nearly to the tips, the auricles narrow, ± divergent; (3) lower spur-petal as well as the two lateral petals densely white-bearded; (4) capsules subglobose, greenish to purplish; and (5) cleistogamous capsules on long ascending peduncles. In east-central Saskatchewan, *V. septentionalis* appears to represent a somewhat larger plant, with larger leaves, and more densely pubescent scapes, petioles and lower leaf surfaces than *V. sororia.* In our initial 1983 collecting year, we confused the two species, placing fruiting material of *V. septentrionalis* together with earlier-collected flowering material of *V. sororia.* But careful field observations and collections of flowering plants in 1984 clearly revealed the coexistence of both species, together with *V. nephrophylla,* at the Carragana sites, and with no apparent intergradation between these acaulescent blue violet taxa. It was also noted here that in a habitat transition from dense aspen woods to open slough edges, the three blue-flowered violet species sorted themselves out ecologically as follows: *V. sororia* was characteristic of the denser, more shaded woods; *V. septentrionalis* of the semi-open but moister wooded edges; and *V. nephrophylla* of the more open, but even moister, slough edges. In other situations, *V. septentrionalis* was noted as more often associated with open coniferous or mixed woods, while *V. sororia* seemed limited to aspen and other deciduous woods.

Viola septentrionalis is an Eastern North American species, previously reported west to northern Michigan (Gleason and Cronquist 1963), southern Wisconsin (Russell 1965), northern Illinois (Mohlenbrock 1978), and as far west as Nebraska and Iowa (Fernald 1950; Scoggan 1978), and to south-central Manitoba (Lowe 1943). However, McGregor et al. (1977) omitted mention of this species on the Great Plains; and Scoggan (1957, 1978) questions the Manitoba reports indicating that they appear to be based upon other species. *V. septentrionalis* also has been reported as far western disjunct populations from southernmost British Columbia (Baird 1942; Hitchcock et al. 1961; Scoggan 1978) and adjacent Washington (Fernald 1950). Scoggan (1978) referred to, but simultaneously questioned, an apparent report of *V. septentrionalis* from McKague, Saskatchewan, which he erroneously attributed to Breitung (1957). The apparent basis for the latter was a CAN collection, *A. J. Breitung no. 230,* originally identified by the collector as *V. nephrophylla,* but subsequently annotated as *V. septentrionalis* by A. E. Porsild, although as such never reported in the literature prior to Scoggan's (1978) questioning reference to it. Scoggan's stated reason for doubting this record was B. Boivin's later annotation of the specimen as *V. canadensis* var. *rugulosa,* but it is the latter annotation that appears most likely erroneous. This McKague collection should be rechecked and *V. septentrionalis* further looked for in eastern Saskatchewan and Manitoba.

New records for *Viola pubescens* and *V. selkirkii*

Hudson (1976) reported, as a new record for Saskatchewan, the Downy Yellow Violet, *V. pubescens* Ait. var. *leiocarpa* (Fern. & Wieg.) Seymour, based on a 1974 collection (*J. H. Hudson no. 2931;* SASK) from 8 miles (= 12.8 km) south of Armit, on an old flood plain of Little Armit River. Further collections have been made by J. H. Hudson from Smoking Tent Creek, 13 km southeast of Hudson Bay (7–T44–R32–W1), 7 August 1983, *4413* (SASK), and by us from along the Little Armit River as follows: 10 km south of Armit (31–T43–R3–W1), 6 June 1984, *Harms & Baker no. 32484;* and 13½ km south of Armit (19–T43–R30–W1), 8 June 1984, *Harms, Hooper & Baker no. 32517;* and 6½ km south of Armit, near jct. of Woody Lake Road and Ridge Road (7–T44–R30–W1), 12 June 1984, *Hooper & Baker s.n.* These additional collections resubstantiate the species natural occurrence in Saskatchewan. While not significantly expanding this violet's known range in the province, they do show it to be locally frequent on moist deep silt soil under rich riverine woods on the flood-plains along the Little Armit River, at middle elevations (1200–1450′) of the north slopes of the Porcupine Hills, from about 6 to 14 km south of Armit.

V. pubescens s. lat. is an eastern North American species extending westward to eastern North Dakota, eastern South Dakota and Nebraska, with isolated

populations in the Black Hills of southwestern South Dakota (Russell 1965; McGregor et al. 1977). The typical variety *pubescens* and variety *eriocarpa* (Schwein.) Nutt. [syn. = *V. eriocarpa* Schwein; *V. pensylvanica* auct., not Michx.?; includ. var. *leiocarpa* (Fern. & Wieg.) Seymour, the glabrous capsule form] appear to have similar overall ranges, although the latter seems to extend somewhat further westward. Scoggan (1957, 1978) reported both varieties as extending westward in Canada to western Manitoba. W. J. Cody (1983 ms. Checklist of Plants of the Riding Mountain National Park, Manitoba. 40 pp.) reported the latter variety (as *V. pensylvanica* var. *leicarpa*) from Riding Mountain National Park. Our collections better fit var. *eriocarpa* than var. *pubescens,* with leaves and stems only moderately pubescent, stems and basal leaves mostly multiple, the plants either slenderly erect or more often tufted and bushy-appearing, stipules lanceolate and elongate, and leaves with 16–38 ($\bar{x}$ = 27) teeth. Since our materials all appear to have glabrous ovaries, they could be recognized as var. *leiocarpa* if this glabrous capsule form is deemed worthy of taxonomic distinction from var. *eriocarpa.*

Another violet species that has been considered rare in Saskatchewan (Maher et al. 1979), as well as rare in the neighboring Prairie Provinces (Argus and White 1978; White and Johnson 1980), is *Viola selkirkii* Pursh (Selkirk's Violet). It was previously recorded in Saskatchewan from Amisk Lake (Breitung 1957), Cumberland House (Dirschl & Dabbs 1969), the Porcupine Hills (Hudson 1976), and Mistatim in the western Pasquia Hills (Maher et al. 1979), based on only a single collection from each locality. But, during recent field studies, we have frequently noted its occurrence and have collected this violet at more than a dozen different localities throughout the Pasquia Hills, northern Porcupine Hills, Nut Hills, and Porcupine Plains, westward to just west of Greenwater Provincial Park. The plants were locally numerous at most sites. Thus, although *V. selkirkii* may be geographically limited in Saskatchewan to the east-central region, the species would appear by no means rare there.

Phytogeographical Considerations

The occurrence of *Viola macloskeyi* spp. *pallens* in east-central Saskatchewan seems best interpreted as a partial bridging or narrowing of an apparent mid-continental gap in the known distribution of this species. That of *V. selkirkii* may similarly be interpreted as an amplification of the apparently sparse mid-continental occurrence of a transcontinental (and in this case also circumboreal) species. Such mid-continental gaps or sparsities in species transcontinental distributions are not uncommon and seem best interpreted either as the results of incomplete remigrations from separate western and eastern Pleistocene refugia, or as discontinuous relicts of formerly continuous west-east distributions following range regressions resulting from probable mid-continental climatic deteriorations (Harms 1983b).

On the other hand, the occurrences in east-central Saskatchewan of *V. sororia, V. septentrionalis, V. incognita* and *V. pubescens* appear to represent examples of relicts from a former post-glacial extension of an eastern deciduous and lake-mixed forest phytogeographical element northwestward into Saskatchewan along the Manitoba Escarpment uplands bordering the southwestern shoreline of former post-glacial Lake Agassiz, as discussed elsewhere (Harms 1983a).

Voucher specimens of all cited records will be filed in the W. P. Fraser Herbarium (SASK), University of Saskatchewan, at Saskatoon, with at least some duplicates of each taxon in the Agriculture Canada Herbarium (DAO), and in the Vascular Plant Herbarium of the National Museum of Natural Sciences (CAN), at Ottawa.

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Received 3 February 1984
Accepted 10 September 1984

Vascular Flora of Abandoned Coal-mined Land, Rocky Mountain Foothills, Alberta

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Russell, W. B. 1985. Vascular flora of abandoned coal-mined land, Rocky Mountain foothills, Alberta. Canadian Field-Naturalist 99(4): 503–516.

A presence list of vascular plant species was compiled for each of six abandoned coal mines in the Rocky Mountain Foothills of west-central Alberta. Species were assigned a gross abundance rating based on their presence (%) in stands: 1 = rare, 2 = frequent, and 3 = abundant. A total of 245 species representing 40 plant families were found on the six minesites. Genera with more than five species were: *Carex* (19), *Salix* (12), *Poa* (9), *Potentilla* (8), *Astragalus* (7), and *Agropyron* (6). Twenty-one species (9% of the flora) occurred on all six of the sites, but only *Achillea millefolium* was abundant on all sites. Richness among the minesites ranged from 94 to 141 species and was correlated with minesite area ($r = 0.80$, $P < 0.05$). The total flora consisted of 206 native and 49 introduced species. Floristic similarity among the minesites ranged from 32 to 68% and was correlated with differences in elevation between the sites ($r = -0.77$, $p < 0.001$). Plants adapted to alpine environments comprised a significant proportion of the minesite floras.

Key Words: Alberta, Coal Mine, Flora, Foothills, Minesite, Rocky Mountains.

Coal mining began in the central foothills of Alberta in 1911 primarily to supply coal to the steam-powered locomotives of the Canadian National Railroad (Lake 1967). When the railroad converted to diesel power in the late 1940's, most of the mines in the region were forced to close down. Little or no attempt was made to revegetate or otherwise reclaim the abandoned landscape (Cormack 1950; Lake 1967). The present paper describes and compares the vascular plant floras of the six major abandoned mines in the region.

The flora of abandoned minesites in the foothills has received little previous study. Root (1976) provided a brief species list for the Cadomin East Mine. No other published species lists have been found. The flora of the un-mined area of the region has received more study and is better known (see Achuff and La Roi 1977; Corns and La Roi 1976; Lesko and Lindsay 1973; Mortimer 1978; Packer and Vitt 1974; See and Bliss 1980; Holland and Coen 1982).

Study Sites

Six abandoned coal mines in the central foothills were studied; Mountain Park Townsite, Mountain Park West Mine, Cadomin East Mine, Nordegg, Sterco/Coal Valley, and Mercoal (Figure 1). Table 1 briefly describes each site.

Although the spoil-heaps on these mines varied in configuration, most were mesa-like mounds of spoil materials which had been levelled on top. They ranged in height from 6 to 60 m and had uniform, or less commonly, irregular slopes ranging from 10 to 45° in angle.

The spoil materials varied greatly within and among the study sites, ranging from silts and clays at Sterco/Coal Valley to gravelly sands at Mountain Park West Mine. They were composed primarily of overburden (sandstone, siltstone, shale) weathering products and/or coal. Analyses of spoils from the Sterco/Coal Valley, Cadomin, and Mountain Park study sites have shown these materials to be generally non-saline, variable in pH, and low in available nitrogen and phosphorus (Russell 1980, 1984; Russell and Takyi 1979). No elemental toxicities have been reported for abandoned mine spoils in this region.

The climate of the region is humid continental with cold winters and cool, short summers. Freezing temperatures can occur in any month. The climate of the Mercoal, Sterco/Coal Valley, and Nordegg study sites is similar to that of the Nordegg Ranger Station (elevation 1326 m): the mean annual temperature is 0.7°C; mean monthly temperature for January is -14.1° and for July 12.6°; annual precipitation is 555 mm, of which 181 mm is snowfall (Alberta Environment 1981). Meteorological data collected at Mountain Park between 1915 and 1924 (Canada Department Marine Fisheries 1915–24) better characterizes the climate of the higher elevation sites at Mountain Park and Cadomin. The mean annual temperature was -2°; mean monthly temperatures for January and July were -17° and 10°, respectively; annual precipitation was 702 mm, of which 231 mm fell in summer (June-August). Thus, the higher elevation sites are generally cooler and receive more precipitation than the lower elevation sites.

Rowe (1972) divides the forest vegetation of the

region into three sections: East Slope section of the Subalpine Region (SA.1) and the Upper Foothills (B.19c) and Lower Foothills (B.10a) sections of the Boreal Forest Region. Subalpine vegetation covers the eastern slopes from 1525 to 2070 m. Climax forests on mesic upland sites are characteristically dominated by *Picea engelmannii* and *Abies lasiocarpa.* At Nordegg mature spruce-fir forests adjoin the minesite. Post-fire *Pinus contorta* forests dominate the vegetation around the other subalpine study sites (Table 1).

Pinus contorta dominates post-fire forests in the Upper Foothills section. The climax forests are distinguished from those of the subalpine zone by the presence of typical *Picea glauca* rather than *P. engelmannii* or *P. engelmannii* × *P. glauca* intermediates. Sterco/Coal Valley lies on the border between the Upper and Lower Foothills. The latter section forms the extensive eastern part of the Boreal Cordilleran Transition Zone (*sensu* Moss 1955) covering low hills and plateaus between 915 and 1220 m. *Pinus contorta* is the distinctive tree species. The greater importance of *Populus tremuloides* and *P. balsamifera* as seral tree species distinguishes these forests from those of the Upper Foothills (Rowe 1972; Achuff and La Roi 1977).

The subalpine study sites, particularly Mountain Park West Mine and Cadomin, are in close proximity to alpine vegetation. Mortimer (1978) described the alpine vegetation of Prospect Mountain, *ca.* 6 km W of the West Mine. Dry, rock tundra vegetation dominated by *Dryas integrifolia* is most extensive. Shrub tundra communities dominated by *Salix arctica, S. barrattiana,* and *D. integrifolia* occur just above treeline. *Cassiope tetragona, Phyllodoce glanduliflora,* and *S. arctica* are common in snow accumulation hollows. Meadow tundra communities are common on moist slopes and flats and are dominated by *D. integrifolia, Elymus innovatus,* and *Artemisia norvegica.*

Packer and Vitt (1974) found numerous species with apparent disjunct distributions in the Mountain Park area, and regarded this area as a glacial refugium during the Wisconsin period. Mortimer (1978) has added species to the list of disjuncts with her work on nearby Prospect Mountain.

Methods

A presence list of vascular plant species was compiled during 1975 and 1976 for each of the six minesites. An attempt was made to include all species growing on spoil-heaps at each site. Voucher specimens were collected of all species and are deposited in the University of Alberta Herbarium (ALTA; accession numbers 84817–85307). Nomenclature follows Moss (1959) and Packer (1974), except for *Agropyron elongatum* and *Elymus junceus*, which follow Scoggan (1978); and *Potentilla bipinnatifida* and *P. pensylvanica,* which follow Kohli and Packer (1976).

Species were assigned a gross abundance rating based on their presence in stands: 1 = rare, 2 = frequent, and 3 = abundant. Stands of varying size $\bar{x}$ = 351 m^2; range 85–1680 m^2) were chosen on each minesite based on the following criteria: (1) occur on spoil materials, (2) uniform slope angle and aspect, and (3) relatively homogeneous plant cover, species composition and spoils. A list was made of all species present in each stand. The number of stands was roughly proportional to the size of the minesite: 15 at Mountain Park Town site, 19 at West Mine, 15 at

TABLE 1. Selected site characteristics of the six abandoned coal mine study sites.

	Mountain Park West Mine	Mountain Park Townsite	Cadomin East Mine	Nordegg	Sterco/ Coal Valley	Mercoal
Location						
Latitude	52°56′N	52°56′N	53°01′N	52°27′N	53°06′N	53°10′N
Longitude	117°18′W	117°17′W	117°18′W	116°05′W	116°48′W	117°05′W
Underground (u) or Strip (s) Mine[1]	s	u	u/s	u/s	s,s	u
Dates of Operation[1]	1945–50	1911–50	1944–52	1910–56	1918–50/ 1922–55	1920–65
Elevation (m ASL)	1810	1780	1675	1500–1600	1408	1343
Area (ha)	34	15	46	12	170	12
Forest Region[2]	Subalpine (SA. 1)	Subalpine (SA. 1)	Subalpine (SA. 1)	Subalpine (SA. 1)	Border of Upper (B19c) and Lower (B19a) Foothills	Upper Foothills (B. 19c)

[1]Sources: Campbell (1967), Lake (1967), and Cormack (1950).
[2]Follows Rowe (1972).

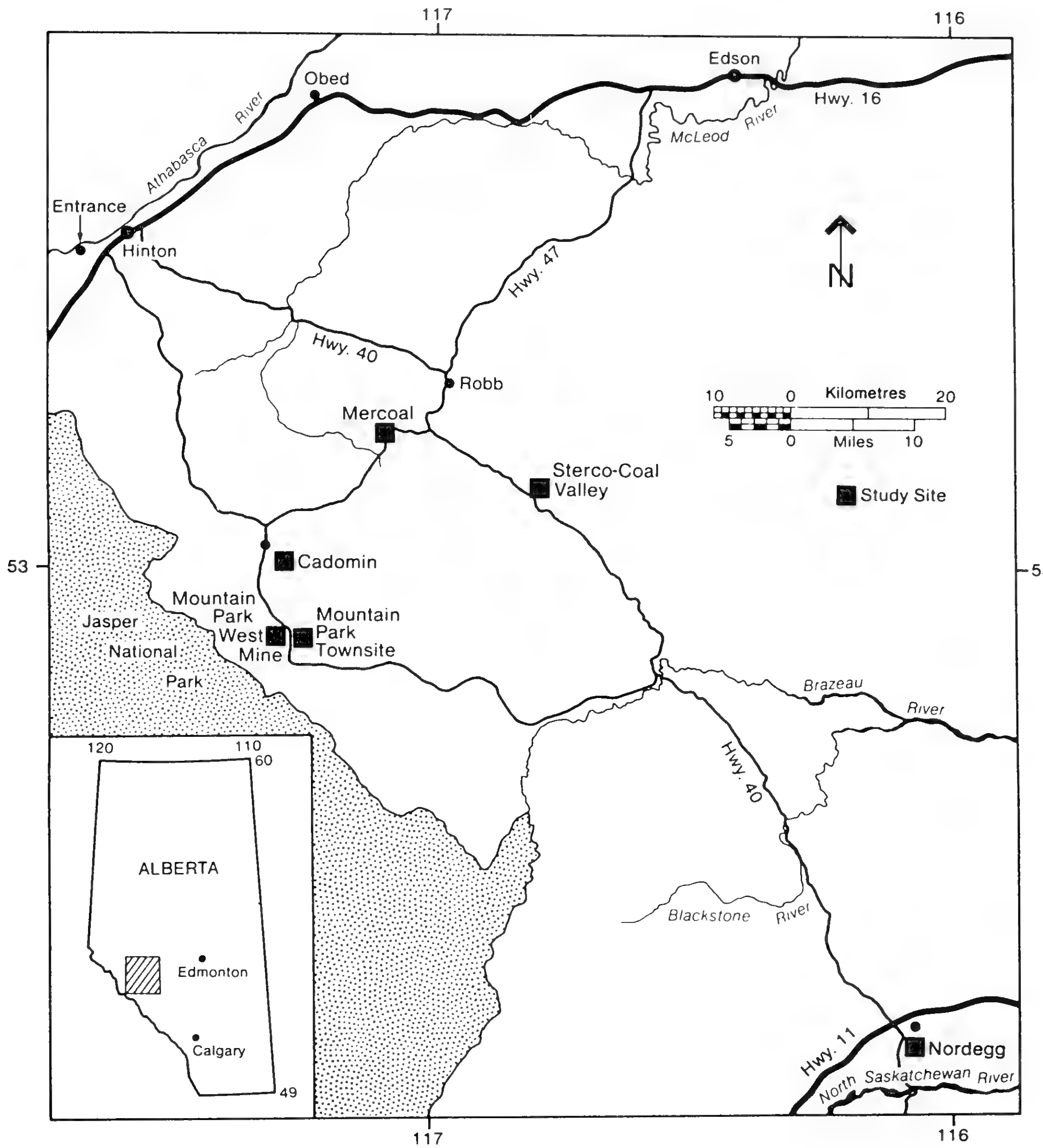

FIGURE 1. Location map of the six abandoned coal mines selected for study.

Cadomin, 15 at Nordegg, 24 at Sterco/Coal Valley, and 10 at Mercoal. Species occurring in $< 15\%$, 15–60%, and $> 60\%$ of stands on a given minesite were considered rare, frequent, and abundant, respectively.

Floristic similarity of the study sites was determined by calculating Sørensen's (1948) coefficient of community for all study site pairs: $CC(A,B) = 200\ c/(a + b)$, where c is the number of species in common and a and b are the total number of species in study sites A and B respectively. For comparative purposes the numbers of native and introduced species in each of the six floras were determined based on Scoggan (1978). All correlations are Spearman rank-order coefficients (r_S; Daniel 1978).

Results and Discussion

A total of 245 species representing 40 families of vascular plants were found on the six abandoned minesites (Table 2). Mountain Park West Mine was the richest site with 141 species and Nordegg was poorest with 94 species. Species richness was significantly correlated with minesite area ($r = 0.80$, $P < 0.05$).

Root (1976) listed 36 vascular plant taxa for the Cadomin East Mine in 1972. In the present study 112 vascular species were found at Cadomin.

The largest plant families were: Compositae (43 species), Gramineae (35), Leguminosae (24), Rosaceae (19), Cyperaceae (19), Cruciferae (16), and Salicaceae (14). Genera with more than five species were: *Carex* (19), *Salix* (12), *Poa* (9), *Potentilla* (8), *Astragalus* (7), and *Agropyron* (6). The predominance of Compositae and Gramineae on mined lands has also been noted by Brierly (1956), Wali and Freeman (1973), Alvarez et al. (1974), Glenn-Lewis (1979), and Jonescu (1979).

Twenty-one species (9% of the flora) were common to all six sites; thus comprising a regional minesite flora: *Achillea millefolium, Agropyron trachycaulum, Agrostis scabra, Aster sibiricus, Epilobium angustifolium, Festuca rubra, F. saximontana, Fragaria virginiana, Gentianella amarella, Poa alpina, P. interior, P. palustris, P. pratensis, Populus balsamifera, Potentilla norvegica, Solidago decumbens, S. multiradiata, Taraxacum officinale, Trifolium pratense, T. repens, and Trisetum spicatum.*

Species which were either frequent or abundant on all six sites were: *Achillea millefolium, Epilobium angustifolium, Festuca saximontana, Poa interior,* and *Taraxacum officinale. A. millefolium* was the only species which was abundant on all sites.

The flora consists of 206 native and 39 introduced species (Table 3). Introduced species were more numerous on the lower elevation sites (Mercoal and Sterco/Coal Valley) and/or on sites which were in close proximity to villages (Mercoal, Sterco/Coal Valley, Mountain Park Townsite). The Mountain Park West Mine, Cadomin, and Nordegg sites were more remote from human settlements and had substantially fewer introduced species.

Introduced species may have entered the region *via* feed for horses or other domestic animals; or they may have escaped from gardens which were known to have been common in mining settlements in the region (Ross 1974). Some species may have invaded along corridors of disturbed ground such as roads or railroads.

Floristic similarity among the six minesites ranged from 32 to 68%, indicating that the floras were neither highly similar nor highly dissimilar to one another (Table 4). The highest similarity was between Mountain Park West Mine and Cadomin (68%) and the lowest between West Mine and Mercoal (32%).

The relatively high similarity of the West Mine and Cadomin floras reflects the fact that both sites are exposed and subalpine, with similar spoils (personal observation). The two Mountain Park sites had a floristic similarity of 57%, which seems low considering their close proximity (only 1.2 km apart and differing only 30 m in elevation). Russell (1980) found strong differences in spoil properties between these sites, which must partially explain why their floras were not more similar.

The coefficients of community were uncorrelated with geographic distance between the sites ($r = -0.24$, $P = 0.20$) but were significantly correlated with differences in elevation between the sites ($r = -0.77$, $P < 0.001$). Thus, floristic similarity among the sites was more closely related to differences in elevation than to differences in geographic distance. The correlation with elevation may be expected since the minesite floras are largely recruited from the surrounding vegetation, which also varies with elevation.

The alpine flora of the Mountain Park area has been studied by Packer and Vitt (1974), Mortimer (1978), and See and Bliss (1980) and is well known. A composite alpine vascular flora taken from the two latter studies (200 species; see Table 2) was compared with the minesite floras using Sorenson's coefficient of community. Similarities of 48%, 38%, 31%, 27%, 20%, and 10% were obtained for Mountain Park West Mine, Cadomin, Mountain Park Townsite, Nordegg, Sterco/Coal Valley, and Mercoal, respectively. Thus, plants adapted to alpine environments occurred on all sites but form a larger proportion of the subalpine cf. upper foothills site floras.

Floristic studies on substrates undergoing primary succession are few in the Canadian Rocky Mountains. The most significant efforts have been on moraines in the main ranges near Mount Robson, *ca* 127 km W of

TABLE 2. Presence and abundance of vascular plant species on the six abandoned minesites: 1 = rare, 2 = frequent, 3 = abundant. Species followed by an asterisk (*) were also found by Mortimer (1978) and/or See and Bliss (1980) in the alpine zone near Mountain Park, Alberta.

	Introduced (I) or Native (N)[1]	Minesites					
		Mountain Park West Mine	Mountain Park Townsite	Cadomin	Nordegg	Sterco, Coal Valley	Mercoal
OPHIOGLOSSACEAE							
Botrychium lunaria (L.) Sw.*	N	2	1	2	1	1	
EQUISETACEAE							
Equisetum arvense L.*	N	2		2	1	2	2
Equisetum scirpoides Michx.*	N	1		1	1		1
Equisetum sylvaticum L.	N					1	
PINACEAE							
Abies lasiocarpa (Hook.) Nutt.*	N	1		1	1		
Juniperus communis L.*	N	1		1	2	1	
Picea engelmannii Parry*/*P. glauca* (Moench) Voss	N	1	1	1	3		
Pinus contorta London var. *latifolia* Engelm.	N	1	1	1	2	1	
JUNCAGINACEAE							
Triglochin palustris L.	N						1
GRAMINEAE							
Agropyron elongatum (Host) Beauv.	I				1		
Agropyron latiglume (Scribn. & Smith) Rydb.*	N	3	3	3		1	1
Agropyron pectiniforme Roem. & Schult.	I				1		1
Agropyron repens (L.) Beauv.	I		2		1	1	2
Agropyron subsecundum (Link) Hitchc.	N			1	1	2	1
Agropyron trachycaulum (Link) Malte	N	3	3	1	3	3	3
Agrostis palustris Huds.	I						1
Agrostis scabra Willd.	N	1	1	1	2	1	1
Bromus inermis Leyss.	I		1	1	1	1	1
Bromus pumpellianus Scribn.*	N	1	1			1	
Calamagrostis canadensis (Michx.) Beauv.	N					1	
Calamagrostis inexpansa A. Gray	N			1		1	1
Calamagrostis neglecta (Ehrh.) Gaertn., Mey. & Scherb.	N		1				
Calamagrostis purpurascens R. Br.*	N	1			1		
Deschampsia caespitosa (L.) Beauv.*	N	2	1	1		1	2
Elymus innovatus Beal*	N	2	1	1	2	2	
Elymus junceus Fisch.	I						1
Festuca baffinensis Polunin*	N	3	1	3	1		
Festuca rubra L.	N(I)	1	3	1	1	2	2
Festuca saximontana Rydb.	N	3	3	3	2	2	2
Hierochloe odorata (L.) Beauv.	N		1		1		1
Hordeum jubatum L.	N		2	1	2	2	3

TABLE 2. Presence and abundance of vascular plant species (*continued*).

	Introduced (I) or Native (N)[1]	Minesites					
		Mountain Park West Mine	Mountain Park Townsite	Cadomin	Nordegg	Sterco, Coal Valley	Mercoal
Phleum alpinum L.*	N	2	1	1	1		
Phleum pratense L.	I		1	1	2	2	2
Poa alpina L.*	N	3	1	2	1	2	1
Poa arctica R. Br.*	N	1		1		1	
Poa compressa L.	I		1			2	1
Poa glauca Vahl	N	1		1	1	1	
Poa interior Rydb.	N	3	3	3	2	2	3
Poa palustris L.	N	1	1	1	2	3	2
Poa pattersonii Vasey*	N	1			1		
Poa pratensis L*	N(I)	1	2	1	2	2	3
Poa secunda Presl	N	3	1		1		
Puccinellia nuttalliana (Schult.) Hitchc.	N					2	
Trisetum spicatum (L.) Richt.*	N	3	2	2	2	2	1
CYPERACEAE							
Carex aenea Fern.	N		1				1
Carex albo-nigra Mack.	N	1					
Carex aperta Boott	N	1					
Carex atrosquama Mack.	N	1	1				
Carex bebbii Olney	N						1
Carex crawfordii Fern.	N		1				1
Carex festivella Mack.*	N	1	1	1			
Carex foenea Willd.	N	1	1	1		1	1
Carex houghtoniana Torr.	N					1	
Carex limnophila F. J. Hermann	N	1					
Carex media R. Br.	N	1					
Carex nardina Fries*	N	1					
Carex obtusata Lilj.	N	1		1			
Carex phaeocephala Piper*	N	1	1	1	1		
Carex podocarpa R. Br.	N	1					
Carex praegracilis W. Boott	N		1				1
Carex richardsonii R. Br.	N				1		
Carex rostrata Stokes	N	1				1	
Carex scopulorum Holm var. *bracteosa* (Bailey) F. J. Hermann	N	1					
JUNCACEAE							
Juncus drummondii E. Meyer*	N	1		1			
Luzula wahlenbergii Rupr.	N	1					
LILIACEAE							
Zygadenus elegans Pursh*	N			1			

TABLE 2. Presence and abundance of vascular plant species (*continued*)

	Introduced (I) or Native (N)[1]	Minesites					
		Mountain Park West Mine	Mountain Park Townsite	Cadomin	Nordegg	Sterco, Coal Valley	Mercoal
IRIDACEAE							
Sisyrinchium montanum Greene	N				1	1	2
ORCHIDACEAE							
Habenaria hyperborea (L.) R. Br.	N				1	1	
Habenaria viridis (L.) R. Br. var. *bracteata* (Muhl.) A. Gray*	N	1					
SALICACEAE							
Populus balsamifera L.	N	1	1	1	3	2	1
Populus tremuloides Michx.	N		1		3	2	1
Salix alaxensis (Anderss.) Coville*	N			1			
Salix arbusculoides Anderss.*	N				1	1	
Salix barclayi Anderss.	N					1	1
Salix barrattiana Hook.*	N	1	1				
Salix bebbiana Sarg.	N				1	1	1
Salix discolor Muhl.	N						1
Salix drummondiana Barratt*	N			1	1	1	1
Salix glauca L.*	N	2	2	2	2	1	
Salix myrtillifolia Anderss.	N				1	1	1
Salix nivalis Hook.*	N	1					
Salix planifolia Pursh	N	1				1	
Salix scouleriana Barratt	N			1	1	1	
BETULACEAE							
Alnus crispa (Ait.) Pursh	N			1			
Betula glandulosa Michx.*	N	1		1			
Corylus cornuta Marsh.	N						1
POLYGONACEAE							
Eriogonum androsaceum Benth.	N	2					
Polygonum aviculare L.	I						1
Polygonum viviparum L.*	N	1					
Rumex acetosella L.	I	1	1			2	1
Rumex alpestris (Scop.) Löve*	I	1	1				
Rumex mexicanus Meisn.	N		2	1		1	1
Rumex occidentalis S. Wats. var. *fenestratus* (Greene) Le Page	N		1			1	1
CHENOPODIACEAE							
Chenopodium album L.	I						1
CARYOPHYLLACEAE							
Arenaria dawsonensis Britt.	N				1	1	1

TABLE 2. Presence and abundance of vascular plant species (*continued*).

	Introduced (I) or Native (N)[1]	Minesites: Mountain Park West Mine	Mountain Park Townsite	Cadomin	Nordegg	Sterco, Coal Valley	Mercoal
Arenaria rubella (Wahlenb.) J. E. Sm.*	N	2	1		2	1	
Cerastium arvense L.	N		1				
Cerastium beeringianum Cham. & Schlect.*	N	2	1	1			
Cerastium vulgatum L. var. *hirsutum* Fries	I						1
Silene acaulis L. var. *exscapa* (All.) DC.*	N	1					
Stellaria crassifolia Ehrh.	N	1					
Stellaria longipes Goldie	N	2			1	1	
Stellaria monantha Hultén*	N	1				1	
RANUNCULACEAE							
Aconitum delphinifolium DC.*	N	1					
Anemone multifida Poir.*	N	1	1	1	1		
Delphinium glaucum S. Wats.*	N		1	1	1		
Ranunculus acris L.	I		2	1		1	1
Ranunculus cymbalaria Pursh	N						1
Thalictrum venulosum Trel.	N						1
PAPAVERACEAE							
Papaver nudicaule L.	I		1				
FUMARIACEAE							
Corydalis aurea Willd.	N					1	
CRUCIFERAE							
Arabis divaricarpa A. Nels.	N				1		
Arabis drummondii A. Gray*	N	1	1	1	1	2	
Arabis hirsuta (L.) Scop.	N				1	2	
Arabis lyrata L.	N		1			1	
Conringia orientalis (L.) Dum.	I					1	
Descurainia richardsonii (Sweet) O. E. Schulz	N		1			1	1
Descurainia sophia (L.) Webb	I		1				
Draba aurea Vahl*	N	2	2	1			
Draba lanceolata Royle	N	1					
Draba oligosperma Hook*	N	2					
Erucastrum gallicum (Willd.) Schulz	I						1
Erysimum cheiranthoides L.	I		1			2	1
Erysimum inconspicuum (S. Wats.) MacM.	N				1	1	
Lepidium ramosissimum A. Nels.	N		1			2	1
Smelowskia calycina (Stephan) C. A. Mey. var. *americana* (Rydb.) Drury & Rollins*	N	1	1	1			
Thlaspi arvense L.	I		1			1	1

TABLE 2. Presence and abundance of vascular plant species (*continued*)

	Introduced (I) or Native (N)[1]	Minesites: Mountain Park West Mine	Mountain Park Townsite	Cadomin	Nordegg	Sterco, Coal Valley	Mercoal
CRASSULACEAE							
Sedum stenopetalum Pursh*	N	1					
SAXIFRAGACEAE							
Parnassia montanensis Fern. & Rydb.	N	1		1			1
Ribes oxyacanthoides L.*	N				1	1	
Saxifraga tricuspidata Rottb.*	N	1					
ROSACEAE							
Dryas drummondii Richards.	N	1		1	2		
Dryas integrifolia M. Vahl*	N	1		1			
Dryas octopetala L.*	N	1		1			
Fragaria virginiana Duchesne*	N	2	2	1	3	3	2
Geum aleppicum Jacq. var. *strictum* (Ait.) Fern.	N						1
Geum macrophyllum Willd.	N	1					
Geum triflorum Pursh	N						1
Potentilla anserina L.	N		1			1	
Potentilla bipinnatifida Dougl. ex Hook.	N						1
Potentilla bipinnatifida Dougl. ex Hook. var. *glabrata* (Hook.) Kohli and Packer	N	1	3				2
Potentilla diversifolia Lehm.*	N	1	1	1			
Potentilla fruticosa L.*	N	1	2	2	1		
Potentilla gracilis Dougl.*	N	1	1	1			
Potentilla nivea L.*	N	1	1	1			
Potentilla norvegica L.	N	1	3	1	2	2	3
Potentilla pensylvanica L.	N	1	1	1	1		1
Rosa acicularis Lindl.	N		1	1	1		
Rosa woodsii Lindl.	N			1	1	1	
Rubus acaulis Michx.	N	1	1				
Rubus strigosus Michx.	N		1	2	2	1	2
LEGUMINOSAE							
Astragalus aboriginum Richards.	N	2		1			
Astragalus alpinus L.*	N	2	2	1	3		
Astragalus eucosmus Robins.	N	1		1			
Astragalus flexuosus Dougl.	N		1				
Astragalus frigidus (L.) A. Gray var. *americanus* (Hook.) S. Wats.	N	1		1	1		
Astragalus striatus Nutt.	N	1		1	1		
Astragalus vexilliflexus Sheld.*	N	2	2	1			
Hedysarum alpinum L.*	N	3	1	1	1		

TABLE 2. Presence and abundance of vascular plant species (*continued*).

	Introduced (I) or Native (N)[1]	Minesites: Mountain Park West Mine	Mountain Park Townsite	Cadomin	Nordegg	Sterco, Coal Valley	Mercoal
Hedysarum mackenzii Richards.*	N	1		1	1		
Hedysarum sulphurescens Rydb.	N				1		
Lathyrus ochroleucus Hook.	N				1		
Melilotus alba Desr.	I					1	1
Melilotus officinalis (L.) Lam.	I					1	1
Oxytropis campestris (L.) DC.*	N	1	1	1	1	1	
Oxytropis deflexa (Pall.) DC.	N	2	2	3	3	2	
Oxytropis podocarpa A. Gray*	N	1					
Oxytropis sericea Nutt. var. *spicata* (Hook.) Barneby	N	1		1	1		
Oxytropis splendens Dougl.*	N	1	2		3		
Trifolium agrarium L.	I						1
Trifolium hybridum L.	I	1	1	1		3	2
Trifolium pratense L.	I	2	3	1	1	3	3
Trifolium repens L.	I	1	1	1	2	2	1
Vicia americana Muhl.	N		1				
Vicia cracca L.	I		1			1	
VIOLACEAE							
Viola adunca J. E. Smith	N					2	
ELAEAGNACEAE							
Shepherdia canadensis (L.) Nutt.	N			1	3		
ONAGRACEAE							
Epilobium angustifolium L.*	N	2	2	2	2	2	2
Epilobium latifolium L.*	N	2		2	1	1	1
UMBELLIFERAE							
Carum carvi L.	I	1		1	1		2
Heracleum lanatum Michx.*	N	1		1			
ERICACEAE							
Arctostaphylos uva-ursi (L.) Spreng.*	N	1	1	1	2	1	
PRIMULACEAE							
Androsace chamaejasme Host*	N	1		1			
Androsace septentrionalis L.*	N	1	1				
GENTIANACEAE							
Gentiana prostrata Haenke var. *americana* Engelm.*	N	1					
Gentianella amarella (L.) Börner ssp. *acuta* (Michx.) J. M. Gillett*	N	2	1	2	1	2	2

TABLE 2. Presence and abundance of vascular plant species (*continued*).

	Introduced (I) or Native (N)[1]	Minesites: Mountain Park West Mine	Mountain Park Townsite	Cadomin	Nordegg	Sterco, Coal Valley	Mercoal
POLEMONIACEAE							
Collomia linearis Nutt.	N		1		1	1	2
HYDROPHYLLACEAE							
Phacelia franklinii (R. Br.) A. Gray	N					1	
Phacelia sericea (Graham) A. Gray*	N	1	2				
BORAGINACEAE							
Lappula echinata Gilib.	I					1	2
Mertensia paniculata (Ait.) G. Don*	N	2	1	1	1		
LABIATAE							
Galeopsis tetrahit L.	I		2			2	
SCROPHULARIACEAE							
Castilleja miniata Dougl.*	N	1		1		1	
Castilleja occidentalis Torr.*	N	1		1			
Euphrasia disjuncta Fern. & Wieg.*	N	1					
Linaria vulgaris Hill	I	1				1	2
Penstemon procerus Dougl.	N	1	1				1
Rhinanthus crista-galli L.	I	1		1			
Veronica alpina L. var. *unalaschcensis* C. & S.*	N	1					
PLANTAGINACEAE							
Plantago major L.	I		1				1
RUBIACEAE							
Galium boreale L.	N		1	1			
CAPRIFOLIACEAE							
Sambucus pubens Michx.	N			1			
CAMPANULACEAE							
Campanula rotundifolia L.*	N		1	1		1	
COMPOSITAE							
Achillea millefolium L.*	N	3	3	3	3	3	3
Agoseris aurantiaca (Hook.) Greene	N			1			
Agoseris glauca (Pursh) Raf.	N	2	1	2		1	
Antennaria lanata (Hook.) Greene*	N	1					
Antennaria neglecta Greene	N	1		1		1	
Antennaria nitida Greene	N	1				1	
Antennaria rosea Greene	N	1					

TABLE 2. Presence and abundance of vascular plant species (*concluded*)

	Introduced (I) or Native (N)[1]	Minesites					
		Mountain Park West Mine	Mountain Park Townsite	Cadomin	Nordegg	Sterco, Coal Valley	Mercoal
Arnica alpina (L.) Olin*	N	1					
Arnica chamissonis Less.	N		1				
Arnica cordifolia Hook.*	N	1	1	1	1		
Arnica lonchophylla Greene	N	1		1			
Artemisia biennis Willd.	I						1
Artemisia borealis Pall.	N	3	2				1
Artemesia norvegica Fries*	N	1		1			
Aster alpinus L.*	N		1				
Aster ciliolatus Lindl.	N				2	2	2
Aster conspicuus Lind.	N				1		
Aster laevis L. var. *geyeri* A. Gray	N				1	1	
Aster sibiricus L.*	N	2	3	2	1	1	1
Chrysanthemum leucanthemum L.	I					1	1
Cirsium arvense (L.) Scop.	I					1	2
Cirsium hookerianum Nutt.	N			1			
Crepis elegans Hook.	N	2		3	3	2	
Crepis nana Richards.*	N	3		3		1	
Crepis runcinata (James) T. & G.	N						1
Erigeron acris L.	N	1		1	1	1	1
Erigeron lonchophyllus Hook.	N						1
Erigeron trifidus Hook.	N	2	1	2			
Haplopappus lyalli A. Gray	N			1			
Hieracium umbellatum L.	N			1		1	
Matricaria matricarioides (Less.) Porter	I						1
Saussurea densa (Hook.) Rydb.*	N	1					
Senecio canus Hook.*	N	1	2	1	1		
Senecio cymbalarioides Nutt.	N			1			1
Senecio indecorus Greene	N	1	1			1	
Senecio lugens Richards.	N	1	1				
Senecio pauciflorus Pursh	N	1					2
Solidago decumbens Greene	N	1	1	2	3	1	1
Solidago lepida DC.	N					1	2
Solidago multiradiata Ait.*	N	2	2	1	2	1	1
Sonchus uliginosus Bieb.	I					2	1
Taraxacum ceratophorum (Ledeb.) DC.*	N	1					
Taraxacum officinale Weber	I	2	3	3	3	3	3
Total number of species		141	107	112	94	107	96

[1]Source: Scoggan (1978).

TABLE 3. Numbers (and percentages) of native and introduced species in the six minesite floras.

Study Site	Native species No. (%)[1]	Introduced species No. (%)[1]
Mountain Park West Mine	132(94)	9(6)
Mountain Park Townsite	89(83)	18(17)
Cadomin	103(92)	9(8)
Nordegg	85(90)	9(10)
Sterco/Coal Valley	85(79)	22(21)
Mercoal	65(68)	31(32)

[1]Percentage of the total number of species found at the study site.

Mountain Park (Cooper 1916; Heusser 1956; Tisdale et al 1966). Two moraines, however, had low floristic similarity with the minesites.

Because of the harsh environmental conditions in high-elevation disturbed sites and the often poor performance of commercially available agronomic species in such environments, native plants have received increased attention in recent years for use in high-elevation reclamation. The following native grasses and legumes were frequent or abundant on at least two of the four subalpine minesites, thus suggesting their potential for high-elevation revegetation: *Agropyron latiglume, A. trachycaulum, Astragalus alpinus, A. striatus, Elymus innovatus, Festuca baffinensis, F. saximontana, Hordeum jubatum, Oxytropis deflexa, O. splendens, Poa alpina, P. interior, P. pratensis,* and *Trisetum spicatum. Trifolium pratense,* an introduced species, also did well on the subalpine sites.

Acknowledgments

I thank George H. La Roi for his help during the study and his comments on the manuscript. John Packer reviewed and made helpful comments on the manuscript. Madeleine Dumais, John Packer, Mary Barkworth, William Dore, and George Angus verified the plant identifications. Financial assistance was received from Alberta Forest Service and from Alberta Fish and Wildlife Division.

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TABLE 4. Comparison of vascular plant floras among the six minesites using Sørensen's coefficient of community.

Study Sites		1	2	3	4	5	6
Mountain Park West Mine	1						
Mountain Park Townsite	2	57					
Cadomin	3	68	59				
Nordegg	4	52	54	64			
Sterco/Coal Valley	5	44	54	52	59		
Mercoal	6	32	49	41	45	60	
Average Coefficient		51	55	57	55	54	45

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Received 7 February 1984
Accepted 18 September 1984

The Biological Flora of Canada.
6. *Matteuccia struthiopteris* (L.) Todaro, Ostrich Fern

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Prange, R. K., and P. von Aderkas. 1985. The Biological Flora of Canada. 6. *Matteuccia struthiopteris* (L.) Todaro, Ostrich Fern. Canadian Field-Naturalist 99(4): 517–532.

Matteuccia struthiopteris (L.) Todaro is a fern which occurs throughout the north temperate and sub-boreal zones of the northern hemisphere including all provinces and territories of Canada, the northern U.S., Japan, China, Siberia west to Scandinavia, Belgium, France and parts of the Alps. Its occurrence may be considered as an indicator of moist eutrophic soils where the water table is generally within 1.5 m of the soil surface. The young vegetative fronds or "fiddleheads" that emerge in the spring have been a traditional part of the diet of the Malecite Indians of New Brunswick. These fiddleheads are an edible, nutritious vegetable that is considered to have potential as a cultivated crop.

Key Words: *Matteuccia struthiopteris*, Ostrich Fern, biology, ecology, physiology, distribution, economic importance.

1. *Name.*

Matteuccia struthiopteris (L.) Todaro 1866; tribe Onocleoideae; Aspidiaceae (Lloyd 1971);
M. pensylvanica (Willd.) Raymond 1950;
Pteretis pensylvanica (Willd.) Fernald 1945;
Ostrich Fern, Fougère-à-l'autruche.

2. *Description of the Mature Plant*

(a) Raunkiaer life-form. Hemi-cryptophyte. Clonal herb with fronds ascending from a short, erect rhizome; fronds dimorphic, with deciduous sterile fronds and persistent fertile fronds; reproduces by spores and rhizomes.

(b) Shoot morphology. Base of the plant a stout erect rhizome, heavily surrounded by the persistent stipe bases, average height 15 cm with maximum of 60 cm if regularly covered by alluvial deposits, deeply perforated by pockets abaxial to frond bases (Mekel 1938); fronds dimorphic, appearing spirally on the erect rhizome; winter-deciduous sterile fronds appearing first, may be followed by persistent fertile fronds; sterile fronds up to 3 m long, stipes up to 4 cm long, deeply channelled on upper side, covered with ramenta when young; blade oblong lanceolate, 17–60 cm wide, gradually reduced toward the base, abruptly reduced at the tip; rachis deeply grooved on the upper side; pinnae broadly linear, acuminate ascending, 20 to many pairs, deeply pinnatifid into oblong, blunt segments, 7–9 pairs of veins in each segment; stout, black, horizontal rhizomes appearing from the base of the erect rhizome, produced from detached meristems located in strict relation to the underlying vasculature (Wardlaw 1943, 1946), covered with black, linear, acuminate, slightly grooved cataphylls, 2–4 cm long, 0.4–1.0 cm wide (Figure 1).

(c) Root morphology. The roots arise adventitiously on the erect and horizontal rhizomes (Ogura 1972). The overall root system is a dense fibrous mass that is restricted to the top 30 cm of soil. Roots have unicellular root hairs and are black and wiry with diameters of 0.6–2.0 mm (Lloyd 1971).

(d) Sporophyll morphology. Persistent fertile fronds shorter than sterile fronds, eventually dark brown when mature, narrowly oblanceolate, 30–70 cm long, 2.5–6 cm wide; stipe and rachis grooved as in sterile frond; pinnae not over 7 mm wide, inrolled margins, venation free; sori dorsal on the veins, several to a segment, covered by the margins, with a membranous indusium; sporangia with 21–30 indurated annulus cells, spores 64 per sporangium, bilateral, chlorophyllous, with perispores, 47–73 μm long (Lloyd 1971).

(e) Subspecies. None.

(f) Varieties and forms. A form *pubescens* (Terry) Clute, characterized by the presence of hairs and scales on the rachis, is known from the Gaspé (Fernald 1935). Tryon (1939) stipulated that if this form was to be recognized, the criteria must be the presence of hairs and scales on the back or sides of the rachis rather than the mere presence of hairs. Morton (1950), who did not recognize the form *pubescens*, pointed out that the presence of

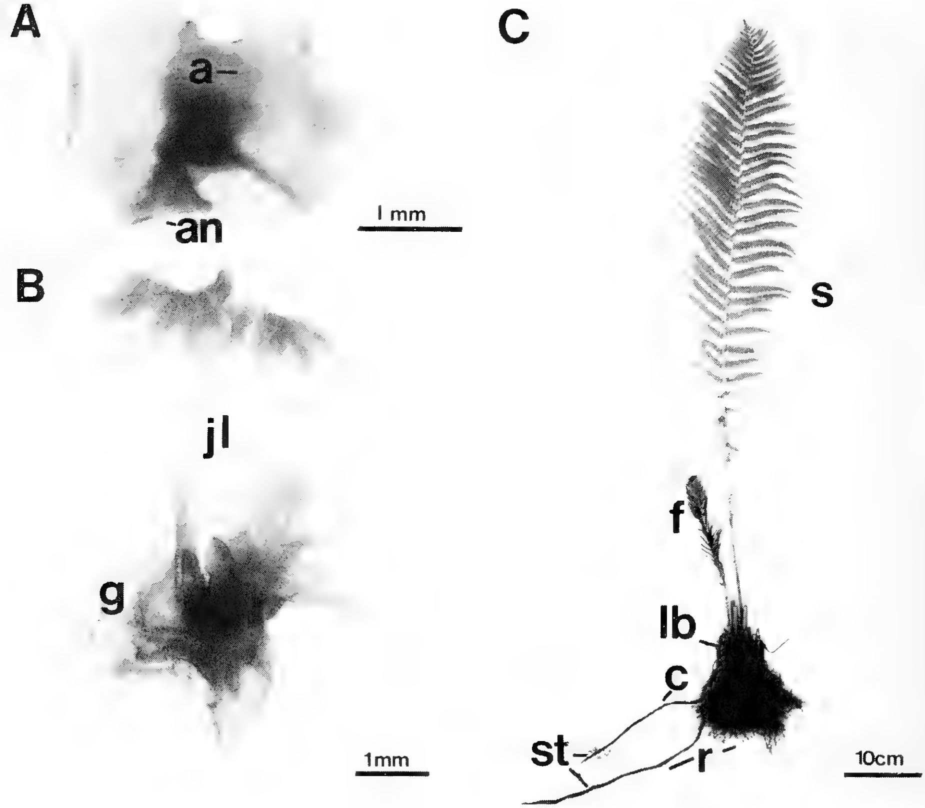

FIGURE 1. Stages in the life-cycle of the Ostrich Fern. A. Gametophyte with archegonia (a) in the central anterior, and antheridia (an) in the basal portions. B. First leaf of juvenile sporophyte (jl) which is still partially dependent on the gametophyte (g) for nutrition. C. Mature sporophyte with large sterile fronds (s) and smaller fertile ones (f). Both types are eventually shed, only the leaf bases (1b) remaining, protecting stem and apex. Stolons (st), which have cataphylls (c) at intervals along their length, arise from the main rhizome. Roots (r) develop extensively from the rhizome but only intermittently along the stolons.

hairs was common to most specimens of *M. struthiopteris*, as did Tryon (1939). Another form of *M. struthiopteris* is *obtusilobata*, which has obtusely shaped pinnules (Fernald 1935). Form *foliacea*, in which the leaves are intermediate between sterile and fertile fronds, and the European equivalents *hypophylloides* and *epiphylloides* (Luerssen 1889) are not thought to constitute good forms, as such intermediate leaves are known to occur in *M. struthiopteris* following surgical removal of the leaves (Goebel 1888) or adverse environmental conditions (Atkinson 1911). Forms recorded for European, but not North American, populations of the Ostrich Fern include *furcata* Baenitz, in which the frond apex has bifurcated, *daedala* Sauter, in which the apex has repeatedly bifurcated, and *serrata* Baenitz, the leaves of which have serrated edges (Hegi 1965).

(g) Ecotypes. None reported.

(h) Chromosome numbers. Numbers (n) of 39 (Fabbri and Menicanti 1970; Kurita 1976; Love 1976) ca. 40 (Britton 1953) and 40 (Friebel 1933; Okuno 1936; Sorsa 1958; Mitui 1965) have been reported.

3. *Distribution and Abundance*

(a) Geographic range. The Ostrich Fern occurs as a native plant throughout the north temperate-sub boreal zone of the northern hemisphere, including North America, Siberia, southern China, Japan, Iran, Scandinavia,

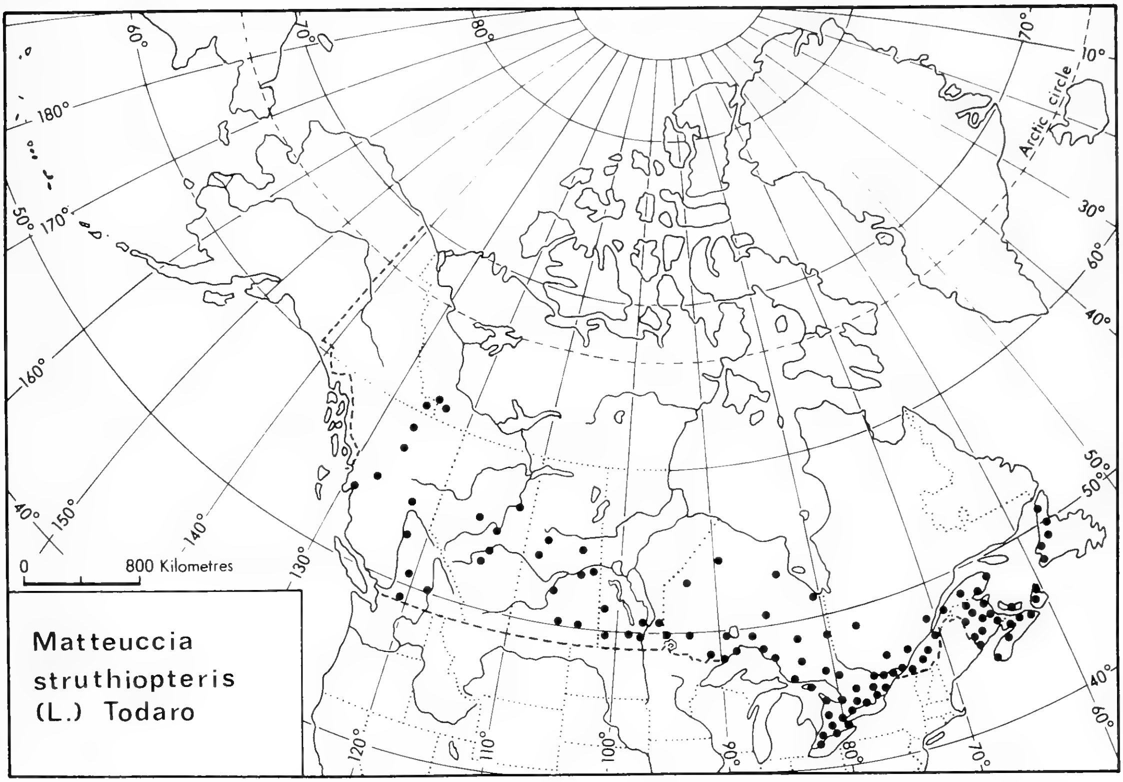

FIGURE 2. Canadian distribution of *Matteuccia struthiopteris* from specimens in DAO (Canada Department of Agriculture, Ottawa, Ontario), CAN (National Museum of Canada, Ottawa, Ontario), NFLD (Memorial University, St. John's, Newfoundland), NSAC (Nova Scotia Agricultural College, Truro, Nova Scotia), ACAD (Acadia University, Wolfville, Nova Scotia) and maps in Cruise (1972), Roland and Smith (1969) and Scotter and Cody (1979).

eastern and central Europe, extending westward to eastern Belgium and France, parts of the Alps, central Yugoslavia and Sicily (Todaro 1866; Lawalrée 1964; Hultén 1968, map; Lloyd 1971). In North America it is distributed from western Newfoundland to southern Alaska, Virginia, Ohio, Indiana, Illinois, Missouri, South Dakota and British Columbia (Lloyd 1971; Scoggan 1978; Tryon and Tryon 1982, map). In Canada, it is found in all provinces and territories (Figure 2) but it is most abundant from New Brunswick west to southern Quebec and southern Ontario.

(b) Altitudinal range. M. struthiopteris grows from near sea level to 4000 m elevation (Lloyd 1971). The highest recorded elevation in Canada is 732 m near Dawson Creek, British Columbia (DAO #200053). In Scandinavia *M. struthiopteris*-dominated grey alder woods are found in the prealpine belt (Hamet-Ahti 1963). They are most common at lower altitudes, such as in the *Alnus incana* forests below 650 m elevation in Røldal, Norway. The Ostrich Fern occurs in plant associations up to 750 m but the abundance decreases (Odland 1981).

4. *Physical Habitat*

(a) Climatic relations. In North America the northern limit of *M. struthiopteris* distribution may be related to temperature. Scoggan (1978) characterized its distribution as low subarctic and high temperate, extending from the -3.91° C isotherm of mean annual temperature in the north, to the ca. 7.21° C isotherm in southern British Columbia and the Niagara peninsula of southern Ontario. Using climatological maps in Fremlin (1974), the northern limit is visually correlated with: i) a minimum 1500 degree-day growing season (above 5.6° C), ii) a growing season (days with mean temperature above 5.6° C) which starts no later than 20 May and ends before 1 October, and iii) mean annual soil temperature 2.2 to 8.3° C as well as a mean summer soil temperature of 8.3

to 15° C. There is no obvious visible correlation between the northern limit of its distribution and frost-free period, first frost, snow cover, precipitation, or daily maximum and minimum temperatures. The indicator values for temperature (T) and continentiality (K) are: T = 5 (moderate; from lowlands to high montane with focus on submontane temperate areas), and K = 4 (suboceanic) (Ellenberg 1978).

The factors controlling the southern limit are harder to define. Warne and Lloyd (1980) suggest that gametophytes are unable to produce archegonia above 20° C, but other laboratory studies indicate that archegonia are regularly produced at temperatures higher than this (Nayar 1968; von Aderkas 1983). There may be a chilling requirement for leaf emergence. Michigan plants require 30 days exposure to ambient winter cold before leaf emergence occurs (Hill 1976). The temperatures are not provided. New Brunswick plants chilled for eight weeks at 1° C have 100% leaf emergence while no leaf emergence occurs in plants that are unchilled (Dykeman 1977). The base temperature for chilling accumulation appears to be much higher than other temperate zone perennials. An initial base temperature estimate is between 18 and 20° C (Prange 1982). The survival of transplants in Florida (Lloyd, personal communication) also indicates that chilling may not be a requirement in the sporophyte and of little consequence in distribution.

(b) Physiographic relations. M. struthiopteris grows mainly on lower slopes and valley floors, forming large stands in floodplain woods (Nichols 1918; Mueller-Dombois 1964; Tessier et al. 1981). In such habitats, *M. struthiopteris* is not subject to excessive climatic variation in air and soil temperature, precipitation, humidity and wind. Although it is most commonly found in full or partial shade, plants growing in full sunlight can be found where the irradiance is naturally less, towards the northern limits of its range, or where it has an environment with high atmospheric humidity and soil moisture near field capacity. However, plants raised under 70% full sun in field trials over a four-year period have larger fronds (Dykeman 1981). The light indicator value (L) is 5 (semi-shade plant, rarely in full light, but usually in more than 10% relative light intensity) (Ellenberg 1978).

The plant is usually found on soil types where the parent material is river plain fluvial deposits or occasionally glacial till or lacustrine deposits. The specific soil type may be a regosol, or a gleyic phase of a luvisol, podzol or brunisol (Clayton et al. 1977). The texture of these soils may vary from fluvial gravels and silts to soils with 59% organic matter (von Aderkas and Bird 1983). Most commonly the plant occurs in areas where soil texture is a loam (Gabrielson 1964; Tessier et al. 1981). The soil moisture regime is predominantly subaquic to perhumid (Clayton et al. 1977).

(c) Nutrient and water relations. M. struthiopteris is considered by some to be a calcicolous species (Wherry 1920, 1921; Fernald 1921; Pesola 1928; Lloyd 1971), although this has not been confirmed by other studies (Gabrielson 1964; Roberts-Pichette 1971; Porfirev 1975; Söyrinki and Saari 1980). The plant is usually absent wherever the parent material is predominantly non-calcareous, e.g. eastern Newfoundland, Atlantic coast of Nova Scotia and southern New Jersey (Chrysler and Edwards 1947). Soils occupied by *M. struthiopteris* tend to have very high calcium content (Prange 1981; Tessier et al. 1981; von Aderkas and Bird 1983).

M. struthiopteris can tolerate soils with a broad range of pH (Prange 1981). Gabrielson (1964) reported that Ostrich Fern occurs on soils with pH ranging from 4–7.5, with the best growth on sites at pH 5.1 and 5.4. Prange (1980) found that increasing soil pH from 5.1 to 6.5 and to 7.4 had no significant effect on frond number, frond length and frond fresh or dry weight in mature plants. The pH indicator value is 7 (from light acidic to light basic soils; never on very acidic sites) (Ellenberg 1978). There is evidence that suggests that very low pH may cause Mn toxicity in ferns (Hou 1950).

M. struthiopteris is a very good indicator of soil moisture conditions since it grows neither on saturated soils nor on soils that dry out during the growing season, preferring moist, well-drained soils instead (Mueller-Dombois 1964; Porfirev 1975). The soil moisture indicator value (F) is 7 (moist but not wet soils) (Ellenberg 1978).

Analysis of vegetative leaves of wild plants near Dresden, German Democratic Republic and plants raised in various botantical gardens indicated that *M. struthiopteris* is a silicon accumulator (Höhne and Richter 1981). Partitioning of mineral elements, between different organs, was studied by Stetsenko and Tabachnyi (1982).

Chemical analyses of macronutrient concentrations in mature fertile and vegetative fronds of 18 different populations of *M. struthiopteris* from Nova Scotia, New Brunswick and Ontario, which had been transplanted to the Nova Scotia Agricultural College four years previously, show greater differences between vegetative and fertile fronds than amongst populations (Table 1). Fertile fronds have higher N, P, K and lower Ca and Mg concentrations than vegetative fronds. A growth chamber study supports these results and also shows that fertile fronds have a nutrient depletion effect on vegetative fronds (Prange 1980).

TABLE 1. Macronutrient concentrations in mature vegetative and fertile fronds of *Matteuccia struthiopteris* from Nova Scotia (NS), New Brunswick (NB) and Ontario (ONT), based on dry weight.[a]

	Concentration (%)									
	N		P		K		Ca		Mg	
Population	Veget	Fert	Veget	Fert	Veget	Fert	Veget	Fert	Veget	Fert
78- 1 (NS)	2.00	3.00	0.42	0.50	0.95	1.52	1.40	0.63	0.40	0.32
78- 2 (NS)	2.38	2.85	0.32	0.49	0.90	1.29	1.87	0.70	0.45	0.34
78- 3 (NS)	2.27	—	0.34	—	1.07	—	1.84	—	0.53	—
78- 4 (NS)	2.19	2.74	0.23	0.49	1.03	1.46	1.93	0.68	0.45	0.27
78- 5 (NS)	1.67	2.51	0.31	0.46	0.88	1.42	1.32	0.61	0.34	0.34
78- 6 (NB)	1.99	2.06	0.32	0.27	0.92	1.17	1.74	0.59	0.53	0.32
78- 7 (NS)	1.76	2.91	0.30	0.48	0.78	1.27	1.44	0.63	0.42	0.33
78- 8 (NS)	1.91	2.98	0.31	0.51	0.88	1.40	1.40	0.67	0.38	0.34
78- 9 (ONT)	2.03	2.94	0.38	0.59	0.79	1.54	1.61	0.84	0.46	0.39
78-10 (NB)	1.67	2.68	0.35	0.51	0.75	1.53	1.69	0.65	0.45	0.33
78-11 (NB)	2.03	2.78	0.29	0.36	0.63	0.91	1.52	0.77	0.49	0.30
78-12 (NB)	1.88	2.76	0.27	0.46	0.67	1.23	1.79	0.59	0.47	0.31
78-13 (NB)	1.89	3.19	0.21	0.43	0.87	1.43	1.87	0.69	0.46	0.32
78-14 (NB)	1.99	2.16	0.29	0.30	1.12	2.22	1.64	0.53	0.43	0.22
78-15 (NB)	2.01	—	0.23	—	0.99	—	1.87	—	0.44	—
78-16 (NB)	1.73	2.78	0.19	0.41	1.21	1.06	1.74	0.57	0.37	0.23
78-17 (NB)	1.73	2.72	0.21	0.47	0.95	1.39	1.64	0.77	0.37	0.31
78-18 (NB)	1.76	2.81	0.27	0.53	0.85	1.43	1.86	0.75	0.52	0.27
Mean	1.94	1.74	0.29	0.45	0.90	1.39	1.68	0.67	0.44	0.31

[a]Tissue analyses were performed by the Soils and Crops Laboratory, Department of Agriculture and Marketing, Truro, Nova Scotia.

Ostrich Fern sporophytes grow better when supplied with nitrate rather than ammonium (Prange and Ormrod 1982). Nitrogen applied only as ammonium has a deleterious effect on frond water relations and growth. Ammonium reduces frond fresh and dry weights, water use, frond water potential and frond diffusive resistance. However, plants grown in nutrient solution containing both ammonium and nitrate grow normally (Prange 1981). Soils with a low pH or that are water-logged inhibit nitrate production and could limit the distribution and growth of *M. struthiopteris.* The nitrogen indicator value (N) is 7 [more often on nitrogen-rich than moderate or poor sites] (Ellenberg 1978).

5. Plant Communities. The Ostrich Fern is found in plant communities which have high moisture and nutrient-rich soil conditions. In temperate zones such conditions are usually found along floodplains.

Mueller-Dombois (1964, 1965), in his study of forest habitat types in southeastern Manitoba, uses *M. struthiopteris* as an indicator of the *Ulmus-Matteuccia* habitat type, which he characterizes as a forest hardwood type occurring on very moist, eutrophic, alluvial bottomlands where soil surfaces are only 0.6 to 1.2 m above the stream level in mid-summer. In a study at the Cent-îles area of the St. Lawrence River, Tessier et al. (1981) identify *M. struthiopteris* as a character species for a variant of the *Acer saccharinum-Fraxinus pennsylvanica-Ulmus americana* plant community. This community is also characterized by having a water table level fluctuating from +10 cm in spring to -50 cm in summer. They consider this variant to be the most developed of the variants within this community, and the last in the sequence of succession of vegetation. *M. struthiopteris* has been found in plant communities other than bottomland hardwood forests. Curtis (1959) lists it in nine Wisconsin plant communities, with maximum frequency (11%) in the northern sedge community. Maycock and Curtis (1960) place *M. struthiopteris* in the dry-mesic, mesic and wet-mesic segments of the boreal conifer-hardwood forests of the Great Lakes region, with frequency values of 5, 10 and 9%, respectively.

In communities where *M. struthiopteris* is present, the dominant tree cover may be deciduous and/or coniferous (Table 2). There may be no tree cover at all, as in the Wisconsin study (Curtis 1959). Species that occur in four of the studies summarized in Table 2 are *Fraxinus nigra, Ulmus americana, Alnus rugosa, Cornus stolonifera, Prunus virginiana* and *Onoclea sensibilis.* Of these, only *F. nigra, U. americana* and *O. sensibilis* appear to reach their greatest frequency in the same communities as *M. struthiopteris.* Although *O. sensibilis* appears on many of the same sites as *M. struthiopteris,* the two species rarely overlap, because the sensitive fern

TABLE 2. Species-stand table showing the frequency of vascular plants in selected plant communities in which *Matteuccia struthiopteris* was present. Data were taken from: 1) wet-mesic stands in boreal conifer-hardwood forests of the Great Lakes region (Maycock and Curtis 1960); 2) northern sedge meadow stands in Wisconsin (Curtis 1959); 3) hardwood forests on alluvial sites in Manitoba (Mueller-Dombois 1964, Appendix IV); 4) hardwood forests on alluvial sites on islands in the St. Lawrence River between Trois-Rivières and Montreal (Tessier et al. 1981); and 5) Ostrich Fern stands in Maine (Gabrielson 1964). Any species occurring in only one study was not included.

Study Number	1	2	3	4	5
Number of stands	43	35	5	?	22
Trees					
*Abies balsamea**	V**	—	—	—	I
Acer saccharinum	—	—	—	V	I
Betula lutea	III	—	—	—	I
Betula papyrifera	V	—	I	—	II
Carya cordiformis	I	—	—	I	—
Fraxinus americana	II	—	—	II	—
F. nigra	III	—	V	I	III-V
F. pennsylvanica	—	—	V	II	—
Picea glauca	V	—	I	—	—
Populus balsamifera	II	—	III	I	—
P. tremuloides	IV	—	II	—	—
Quercus macrocarpa	I	—	I	—	—
Q. rubra	III	—	—	—	I
Thuja occidentalis	IV	—	—	—	I
Tilia americana	II	—	—	I	—
Tsuga canadensis	III	—	—	—	I
Ulmus americana	III	—	V	IV	I
Shrubs					
Alnus rugosa	III	—	I	I	I
Cornus stolonifera	I	—	IV	III	I
Corylus cornuta	IV	—	III	—	I
Ilex verticillata	I	—	—	II	—
Lonicera oblongifolia	I	—	I	—	—
Prunus virginiana	IV	—	V	I	I
Rhamnus alnifolia	I	—	III	—	—
Ribes triste	III	—	IV	—	—
Rubus idaeus	III	—	III	—	I
Spiraea alba	I	III	—	I	I
Symphoricarpos occidentalis	I	—	I	—	—
Viburnum cassinoides	I	—	—	I	—
V. lentago	I	—	V	I	—
V. rafinesquianum	I	—	III	—	—
V. opulus var. *trilobum*	I	—	V	—	—
Herbs					
Achillea millefolium	I	—	—	—	I
Actaea pachypoda	I	—	—	—	I
A. rubra	IV	—	III	—	—
Alopecurus pratensis	III	I	—	—	—
Amphicarpa bracteata	I	—	—	II	—
Anemone quinquefolia	III	—	I	—	—
Apocynum androsaemifolium	II	—	—	I	I
Aralia nudicaulis	V	—	III	—	I
Arisaema atrorubens	II	—	—	III	I
Asarum canadense	II	—	IV	—	—
Aster ciliolatus	II	—	II	—	—
A. lateriflorus	III	—	—	I	—
A. puniceus	I	III	—	—	—
Athyrium filix-femina	IV	—	—	—	II
Botrychium virginianum	III	—	I	—	—
Brachyelytrum erectum	III	—	—	II	—

TABLE 2. Species-stand table (concluded).

TABLE 2. Species-stand table (*concluded*)

Study Number	1	2	3	4	5
Number of stands	43	35	5	?	22
Calamagrostis canadensis	I	V	I	I	—
Caltha palustris	I	—	II	—	—
Carex intumescens	II	—	—	I	—
Cicuta maculata	I	II	—	—	—
Cinna latifolia	I	—	IV	—	—
Cirsium arvense	I	—	—	—	I
Convolvulus sepium	—	—	—	I	I
Echinocystis lobata	—	—	—	I	I
Equisetum arvense	III	II	—	—	I
E. sylvaticum	III	—	I	—	—
Eupatorium purpureum	I	V	—	II	—
Fragaria virginiana	V	—	III	—	I
Galium boreale	I	—	III	—	—
G. trifidum	—	II	—	I	—
G. triflorum	IV	—	V	—	—
Gaultheria procumbens	I	—	—	—	I
Heracleum lanatum	I	—	I	—	I
Impatiens capensis	II	II	—	II	—
Iris versicolor	—	—	III	I	I
Laportea canadensis	I	—	—	V	—
Lilium canadense	I	—	—	—	I
Lycopus americanus	I	III	—	I	—
L. uniflorus	I	III	—	—	—
Lysimachia ciliata	—	—	—	I	I
Maianthemum canadense	V	—	IV	—	II
Matteuccia struthiopteris	**I**	**I**	**V**	**II**	**V**
Mentha arvensis	—	—	III	I	—
Mimulus ringens	—	I	—	I	—
Mitella nuda	IV	—	I	—	—
Onoclea sensibilis	I	III	—	V	III-V
Osmunda claytoniana	II	—	—	—	I
O. regalis	—	—	—	III	I
Petasites palmatus	III	—	I	—	—
Polygonum coccineum	—	II	—	I	—
P. sagittatum	I	III	—	—	—
Polypodium virginianum	I	—	—	I	—
Prenanthes alba	II	—	—	—	I
Rhus radicans	I	—	—	—	II
Rubus pubescens	V	—	V	I	—
Sanicula marilandica	III	—	II	—	—
Scutellaria lateriflora	I	—	—	I	—
Stellaria media	—	—	—	III	I
Taraxacum officinale	II	—	—	—	I
Thalictrum dasycarpum	I	II	—	—	—
T. pubescens	—	—	—	IV	III-V
Thelypteris palustris	—	III	—	II	—
Uvularia sessilifolia	II	—	—	—	II
Vicia americana	I	—	I	—	—
Viola pubescens	II	—	—	—	I

*Nomenclature follows Scoggan (1978).
**Braun-Blanquet frequency (constancy) scale: I, < 20%; II, 20.1 to 40%; III, 40.1 to 60%; IV, 60.1 to 80%; V, 80.1 to 100%.

generally occupies wetter microtopographic sites (Roberts-Pichette 1971; Tessier et al. 1981). These sites are subject to greater spring flooding (Tessier et al. 1981).

In Eurasia, *M. struthiopteris* occurs in sites very similar to those in North America, although the associated species are different (Englert 1970; Porfirev 1975). In central European forest stands, *M. struthiopteris* is considered a characteristic species of Alno-Padion (*Alnus incana-Prunus padus*) (Mueller-Dombois and Ellenberg 1974; Rasbach et al. 1978) or Alno-Ulmion (*Alnus incana-Ulmus glabra*) (Hamet-Ahti 1963, Ellenberg 1978) plant alliances. Generally, such forest types are found by river beds, brooks and other places with a high, stable water table. The tree layer may be dominated by *Alnus incana, Betula pubescens, Fraxinus excelsior, Picea abies,* or *Ulmus glabra* (Odland 1981). A detailed study by Odland (1981) of plant communities of Roldal, Norway, indicated that *M. struthiopteris* is dominant in two types of *Alnus incana* forest; tall herb/fern type and *M. struthiopteris* type. The latter is much poorer in species (21.7 spp/25 m^2) than the former 30.5 spp./25 m^2), due to the total dominance of the Ostrich Fern. The *M. struthiopteris* type of *Alnus incana* forest is restricted to shady, moist, hillsides and according to Odland (1981) it should be treated as a separate association from alluvial forests. In the U.S.S.R., *M. struthiopteris* is found in coniferous, mixed and deciduous forests which are found in localities with high water table and eutrophic conditions suitable for the nitrophilous plants of these communities (Porfirev 1975).

Other descriptions of plant communities in which *M. struthiopteris* is found are also referred to in Nichols (1918), Szafer (1966), Walter (1974), Taylor and MacBryde (1977), Soyrinki and Saari (1980), von Aderkas and Bird (1983) and Gauvin and Bouchard (1983).

6. *Growth and development*

(a) Morphology. Embryogenesis and juvenile development in the Ostrich Fern occur in a manner typical of other leptosporangiate ferns (Campbell 1887). *M. struthiopteris* develops three kinds of leaves: cataphylls, (found only on stolons), sterile and fertile fronds. Fertile fronds do not appear until the third year, and then only irregularly. Sobey and Barkhouse (1977) report a maximum growth rate of less than 1 cm/yr for "thick rhizomes" which probably are the thickened erect rhizomes. Dykeman (1982a) reports erect rhizome growth rates of 0.5 to 2.0 cm/yr. The growth rate of horizontal rhizomes is much greater, and plants with intact rhizomes up to 3 m in length have been excavated in Hants County, Nova Scotia (von Aderkas, unpublished). Horizontal rhizomes are produced from detached meristems on the stem after one year. Detached meristems are groups of meristematic cells derived from the apical meristem, occurring at the junction of two meristeles. The longevity of horizontal and erect rhizomes is unknown.

(b) Physiology. Prange (1980) has shown that vegetative fronds generally complete their elongation in 15 to 20 days. Both high photosynthetic photon flux density (PPFD) (418 μmol m^{-2}s^{-1}), and low moisture (30–60% of field capacity) reduces frond height. Low soil moisture also decreases the fresh and dry weights of both vegetative and fertile fronds, thus providing further evidence that soil moisture is a critical factor limiting the plant's distribution.

Measurements of photosynthesis, dark respiration, frond diffusive resistance, water potential, osmotic potential and pressure potential in well-watered fronds of various ages up to 28 days old have been reported by Prange et al. (1984). These physiological measurements are summarized in Table 3. In fronds up to nine days of age, nighttime diffusive resistances are similar to daytime resistances (ca. 550 s m^{-1}). These then increase to

TABLE 3. Net photosynethsis at light saturation (600 μmol m^{-2} s^{-1}), dark respiration, light compensation point, pre-dawn frond water potential, osmotic potential, pressure potential, diffusive resistance and mid-day diffusive resistance in fronds from 3 to 24 days old (mean ± standard error) (adapted from Prange et al. 1984).

Parameter	Frond age (days) 3	6–8	15–16	22–24
Net photosynthesis (μg CO_2 m^{-2} s^{-1})	—	134±6	221±10	195±15
Respiration (μg CO_2 m^{-2} s^{-1})	—	71±2	16±1	9±2
Light compensation point (μmol m^{-2} s^{-1})	—	50	10	7
Pre-dawn frond water potential (kPa)	-332±57	-103±44	-379±29	-390±65
Pre-dawn frond osmotic potential (kPa)	-837±72	-942±64	-1892±129	-1493±51
Pre-dawn pressure potential (kPa)	505±33	839±73	1513±103	1104±5
Pre-dawn diffusive resistance (s m^{-1})	—	557±26	941±100	1246±99
Mid-day diffusive resistance (s m^{-1})	—	365±12	338±19	389±17

ca. 1250 s m^{-1} at full frond expansion. This shift could be due to either cuticular wax deposition or a change in stomatal functioning. Osmotic and pressure potentials reach their lowest and highest values, respectively, as the frond reaches full expansion at ca. 16 days. At this time, net photosynthesis peaks and then gradually declines, while dark respiration reaches a low steady value. The results indicate that *M. struthiopteris* is a typical shade-adapted plant with a maximum net photosynthetic rate of ca. 220 $\mu g\ CO_2\ m^{-2}\ s^{-1}$.

The effect of a mild water stress on immature and mature *M. struthiopteris* fronds has been reported in terms of water status and frond elongation (Prange and Ormrod 1983) and frond gas exchange (Prange et al. 1983). A mild soil water stress of ca. -0.15 MPa is sufficient to significantly reduce elongation in immature fronds and net photosynthesis, dark respiration, internal carbon dioxide concentration and diffusive conductance in fronds of both ages. The residual resistance to carbon dioxide flux is not significantly affected by either mild water stress or frond age. A wild water stress reduces frond water potential in immature fronds but produces an increase in mature fronds, which is the reverse of the typical response. In most agricultural plants, wilting occurs in the older leaves first.

(c) Phenology. The swelling of the croziers begins towards the end of April in Nova Scotia, with the first leaves appearing above the crown by the middle of May. In cooler areas this is delayed. Full leaf expansion occurs by the middle of June, with fertile fronds appearing late in that month through to the beginning of autumn. Smaller sterile fronds often appear towards the end of the summer. The fronds begin to brown in early autumn and die back with the first frost. The leaves do not abscise, but remain attached to the leaf-bases until removed either by flooding, or some other agent. In subsequent years, the large leaf bases serve as storage organs or trophopods (Wagner and Johnson 1983).

From autumn until spring the crown remains dormant. During autumn and winter, dormant plants were brought into the greenhouse at weekly intervals. The mean weekly air temperature in the greenhouse ranged between 18.2 and 23.0°C. The minimum PPFD was ca. 400 $\mu mol\ m^{-2}\ s^{-1}$ provided by high pressure sodium lights. These plants produced some new emergent fronds on 4 November and reached 100% emergence by 18 November. Throughout the rest of the winter the frond emergence rate, expressed as the daily average rate of development as defined by Nooden and Weber (1978), continued to increase (Prange, unpublished). This suggests that the plants continued to benefit from exposure to cold after the chilling requirement, to break dormancy, was satisfied. Small crowns and horizontal rhizomes appear to have little or no dormancy because they continue to grow in the autumn if placed in a greenhouse or growth chamber.

7. *Reproduction*

(a) Spore production and dispersal. Sporangia develop on the underside of the fertile frond, the pinnules of which curl around the sori, therby giving protection (Bower 1923). The gradate sori are minutely indusiate. Meiosis occurs during early summer, for example, 1 July in southern Ontario (Britton 1953). Each sporangium produces 64 spores. Spores are mature by late summer or the beginning of the autumn, but are not released until winter and the following spring. The sporangia open by the drying of a slightly oblique annulus. Initially, the propagules are both whole sporangia and free spores, as excavation of snow profiles in Massachusetts revealed (Klekowski 1979), but later, as the surrounding pinnule breaks down, free spores are released. Each fertile frond is estimated to produce between $1 \times 10^5 = 1 \times 10^6$ spores (Farrar 1976).

Dispersal is by two methods: air and water dispersal of spores, and water dispersal of crowns and/or stolons from populations along riverbanks. Establishment of young plants from gametophytes has not been studied, for in spite of the prodigious production of spores per fertile frond, very few spores germinate. Gametophyte development in nature is dependent on conditions of high humidity (von Aderkas 1983).

The production of fertile fronds per plant is quite variable. Only 1% of shaded plants along the floodplain of the Five Mile River near South Maitland, Nova Scotia developed fertile fronds (von Aderkas, unpublished). The number of fertile fronds produced per plant is also proportional to the size of the plant. It is our observation that in conditions of direct sunlight, a much higher percentage of plants develop fertile fronds. Growth chamber studies show that fertile fronds production is greatest under high PPFD (418 $\mu mol\ m^{-2}\ s^{-1}$), and soil moisture conditions [100% field capacity] (Prange 1980).

(b) Spore viability and germination. Fresh spores of *M. struthiopteris* germinate at temperatures from 5 to 30°C (Klebs 1917; Hill and Wagner 1974; Warne and Lloyd 1980). The germination rate of spores shed in December and those shed in March stayed at 95% (Farrar 1976). Development of a gametophyte with sex organs takes from two to three weeks in laboratory conditions (von Aderkas 1983). The germination of *M. struthiopteris* spores is light-dependent (Klebs 1916; Pietrykowska 1962; Mohr and Holl 1964; Jarvis and Wilkins 1973). A low percentage of spores, e.g. less than 43%, is able to germinate in the dark but light greatly

increases the germination rate, e.g. 70–91%. All wavelengths between 400 and 750 mm promote germination, but two major peaks of promotion occur at 550 nm and 625 nm, and a minor peak at 450 nm (Jarvis and Wilkins 1973).

Gantt and Arnott (1965) and Jarvis and Wilkins (1973) report that spore viability is maintained for at least 18 months and up to two years when stored in a dark, dry environment at 3 to 5° C. Jarvis and Wilkins (1973) report reduced viability at -10° C or room temperature. Barker and White (1964) freeze-dried spores and observed no drop in viability after three months storage.

Gantt and Arnott (1965) examined germination and early gametophyte growth using histochemistry and electron microscopy. They showed that the dormant spores contain no starch but it accumulates in the chloroplasts after the spores are exposed to light. During germination the abundant protein granules are broken down and disappear. The degradation of protein body reserves by proteolytic enzyme activity has been studied by Cohen and DeMaggio (1983).

(c) Gametophyte development. The prothallus initially develops into a small heart-shaped plant. Detailed description of the cell pattern lineages was recorded by Döpp (1927). Under controlled conditions sexual maturity is attained approximately three weeks after germination. Sex expression of Ostrich Fern populations is largely determined by density and age (von Aderkas 1983). Individual plants develop slower than plants at moderate densitites. With increasing age, more hermaphrodites are observed, allowing the possibility of intra-and inter-gametophytic mating. Gametophytes respond to a bracken pheromone, antheridiogen, which induces male sex organ formation (Döpp 1950), but do not produce such a compound themselves (Döpp 1962). Strictly male plants arise from gametophytes arrested at a juvenile stage (von Aderkas 1983). Plants will grow in either liquid or solid inorganic media. Mutations in gametophyte development have been studied from populations beside polluted and unpolluted rivers in Massachusetts. The frequency of somatic mutations is much higher along the river known to be contaminated with high levels of polychlorinated biphenyls (Klekowski and Klekowksi 1982).

Gametophytes raised in culture frequently give rise to apogamous features such as single leaves, sporangia and glandular scales. This sort of development is markedly promoted by sucrose. However, the occurrence of complete apogamous plants is very rare (von Aderkas 1984a).

In culture, gametophytes may develop from the cut edges of juvenile leaves and, when mated, produce polyploid sporophytes (von Aderkas, unpublished).

In the wild, gametophytes develop very slowly and consequently the proportion of female plants is much lower than in culture (von Aderkas 1983). Prothalli are particularly susceptible to desiccation from which they do not recover (Pickett 1914).

(d) Vegetative reproduction. Stolons develop from detached meristems on the rhizome stem and generally grow parallel to the soil surface. The stimulus for reorientation of the apex of the stolon and the onset of crown development is not known, but may be brought about by exposure of the apex to light. A stand of *M. struthiopteris* is spread by the colonization of the surrounding soil by these stolons. If the apex of the stolon is damaged, plants develop from the detached meristems.

Studies of detached meristems (Wardlaw and Alsopp 1948) suggest that emergence may be affected by soil oxygen concentration. The rate of development increases with O_2 concentration up to 45%. Soil pH may also play a role (Prange 1983). Soil media with a pH between 6.5 and 7.1 are the most productive in terms of emerged meristems, time of emergence, plant numbers and fresh weight.

8. *Population Structure and Dynamics*

(a) Dispersion patterns. Populations of sporophytes within a community generally show a clumped or contagious distribution. In denser stands, in which *M. struthiopteris* is the dominant species, frequently found along floodplains in parts of the Maritimes, there is a strong tendency towards a regular distribution in which self-shading plays an important role. When soil moisture varies on a microenvironmental level from aquic to perhumid, patchiness is readily apparent.

(b) Age distribution. Age-specific mortality rates and longevity in different habitats have not been reported for the Ostrich Fern. Sporophytes are thought to be "potentially immortal", as the distribution of plants showing the same type of heterogeneity for a somatic mutation may be very extensive within a population (Klekowski and Klekowski 1982). By vegetative propagation, a clone is established which may form quite an extensive stand. At present, it is difficult to determine the age of individual ramets, particularly erect rhizomes, as there are neither clear age indicators, such as yearly additions of regular numbers of leaf bases, nor visible differences

TABLE 4. Width distribution of sporophytes selected from a stand of *Matteuccia struthiopteris* along the Five Mile River, Hants County, Nova Scotia, Canada (N = 140) (von Aderkas, unpublished).

	Plant width (cm)							
	0–1	1–2	2–3	3–4	4–5	5–6	6–7	7+
Percentage of plants	0	10.0	11.4	27.1	25.6	22.1	3.5	0

between annual additions beyond the present year. The difficulties of ageing ferns by numbers of existing leaf bases is clearly outlined by Tanner (1983).

(c) Size distribution. Preliminary data from a Nova Scotia population in an *Ulmus-Fraxinus-Acer* community along a floodplain indicates that size distribution is rather skewed (Table 4). The smaller plants (1–3 cm) are the recent additions to the population. There is a lack of plants smaller than 1 cm in width because new additions are from underground rhizomes which turn upwards, and not from sporophytes of sexual origin. Maximum plant width did not exceed 7 cm. This size limit does not represent a maximum, which once attained is followed by rhizome death. The growth habit of erect rhizomes is much like that of a tree fern: once a certain width is reached, the plant continues to grow upwards, retaining approximately the same width. The average height of fronds in this same population was 85 cm, ranging in final size from 33–159 cm. The average number of fronds per plant was 6.75 ± 2.3 and ranging from 2–13. The average total leaf dry weight per plant was 22.9 g, ranging from 1.6 to 72.3 g (von Aderkas, unpublished). Under controlled cold room conditions, large individual crowns have a greater survival rate during dormancy than small individual crowns (Prange 1982).

(d) Growth and turnover rates. Populations of the Ostrich Fern are long-lived. In Raifa, U.S.S.R., Porfirev (1975) noted that *M. struthiopteris* maintained the same ground cover from 1925 to 1956, in spite of the change of the plant associates from those of a *Picea* stand, in which *Tilia* was sub-dominant, to one in which *Tilia* was dominant and *Picea* sub-dominant. This he took as further evidence that soil moisture conditions are more important than the type of plant community in determining the presence or absence of *M. struthiopteris.*

(e) Successional role. Braun (1950) states that the successional series of communities on floodplains in the Hemlock-White Pine-Northern Hardwoods Region includes transition from elm-black ash to maple-elm-basswood-yellow birch, which in turn becomes maple-yellow birch-hemlock or maple forest. The herbaceous layer of the first community, elm-black ash, includes an abundance of *M. struthiopteris.* In subsequent seral stages, which reflect increasing elevation, less flooding and lower water tables, *M. struthiopteris* is not mentioned. Tessier et al. (1981) described the succession of vegetation on islands in the St. Lawrence River that are subjected to periodic flooding and concluded that the community sequence is controlled primarily by the depth of the water table. The climax floodplain community, which contains *M. struthiopteris,* along with *Acer saccharinum, Fraxinus pennsylvanica* and *Ulmus americana,* is mainly determined by small changes in microtopography in relation to the water table. Recently, the almost complete destruction of *Ulmus americana* by Dutch elm disease has led to increases in the other dominants.

9. *Interaction with other Species*

(a) Competition. In the most vigorous stands of *M. struthiopteris,* the plants form a dense stand that reduces light at ground level to a level insufficient for growth of competitors. If the soil becomes water-logged, *M. struthiopteris* is frequently replaced by *Onoclea sensibilis.* On sites that are drier or receive more radiation, *M. struthiopteris* is replaced by *Solidago, Rubus* and *Eupatorium* species, and grasses (Dykeman 1982a).

(b) Symbiosis. Boullard (1957) reported the presence of endomycorrhizae in the sporophyte of *M. struthiopteris.* In a more detailed study of roots, Berch and Kendrick (1982) quite commonly found unspecified vesicular arbuscular mycorrhizae. No ectomycorrhizae were observed, but a variety of fungal endophytes were present. None of these endophytes are necessary for the growth of the plant as sporophytes grow quite well in sterile culture. No mycorrhizal organisms are associated with gametophytes (Boullard 1957).

(c) Predation and parasitism. The following insects are listed as feeding on *M. struthiopteris* (Balick et al. 1978): Diptera — *Chirosia hystricina* Rondani; Aphididae — *Amphorophora ampullata* Buckton, *A. laingi* Mason; Hymenoptera — *Blasticotoma filiceti* Klug, *Strombocerus delicatulus* (Fallen), *S. lineata* (Christ.), *S. struthiopteridis* (Forsius); and Lepidoptera — *Papipema* sp.

Various diseases and fungi have been recorded on plants by Gregor (1938), Stevenson (1945), Anonymous

(1960), Connors (1967), Gourley (1983) and von Aderkas and Brewer (1983). *M. struthiopteris* is the host for the uredinial and telial stages of the rust *Uredinopsis struthiopteridis* Stormer ex Diet. Other fungi reported include: *Herpobasidium struthiopterides* (Rostr.) Lind., *Sclerotium deciduum* Davis, *Dothidella osmundae* (Pk. and Clint.) Sacc., *Sphaerothyrium filicinum* Bub., *Taphrina struthiopteris* Nishida (leaf blister), *Phoma exigua* Desm. var. *foveata* (gangrene), *Ceratobasidium anceps* (Bres. and Sacc.) Jackson, *Cyphella capula* (Holmskj.) Fr., *Dasyscyphus carestianus* (Rabh.) Sacc., *Leptothyrium litigiosum* (Desm.) Sacc. and *Solenia filicinia* Pk.

Dodder, *Cuscuta europaea* L., has been found to parasitize the fern (Gams 1938).

(d) Toxicity and allelopathy. None reported to date.

10. *Evolution and Migration.* There are two other species in the genus (Lloyd 1971): *M. orientalis* (Hook.) Trev., and *M. intermedia* C. Chr. The former occurs in Siberia, Japan, Korea, throughout China to Assam, India and Sikkim. The latter is found from south-central and southeastern China to Tibet, Sikkim and northeastern India. Many of the morphological characteristics of *M. intermedia* are intermediate between *M. struthiopteris* and *M. orientalis.* Lloyd (1971) suggests that *M. intermedia* is a tetraploid species, and probably an allopolyploid derivative of a cross between diploid *M. orientalis* and *M. struthiopteris.* He also suggests that *M. intermedia* has two separate origins by different hybridizations of the same two parent species because there are two morphological forms of *M. intermedia* that are geographically separated.

In North America the Ostrich Fern probably migrated into the northern part of its habitat from the southern United States following the retreat of the last glacial ice.

11. *Response Behavior*

(a) Fire. M. struthiopteris does not occur in fire-prone habitats.

(b) Grazing and harvesting. Sheep and cattle are known to eat both young and old fronds. Continual grazing leads to reduced vigour and eventually death of the plant. One of the effects of repeated annual harvesting in the Fredericton area of New Brunswick is a drop in the vigour of plants (Roberts-Pichette 1971).

(c) Flooding. When *M. struthiopteris* is found along floodplains, it is subject to inundations, especially in the spring. Flooding probably benefits the Ostrich Fern by depositing new soil and organic debris (Dykeman 1982a). Freshets also play a role in dispersal of rhizomes.

(d) Drought. The effect of drought on the sporophyte has not been investigated. However, in nature gametophytes growing on soil which dried out as the growing season progressed quickly dried up and died (von Aderkas 1983). This decrease in humidity had no noticeable effect on the surrounding sporophytes.

(e) Herbicides. Doohan (1982) screened herbicides for the Ostrich Fern and observed no injury when Glyphosate and Simazine were applied to dormant crowns. Glyphosate, Simazine, Dicamba, Cyanazine and Terbacil all injured the Ostrich Fern when applied to expanded foliage.

12. *Relationship to Man*

The young fronds of *M. struthiopteris* have been eaten in North America by the indigenous population. They have been used as a spring tonic (Smith 1957). There is some evidence that the Abenaki Indians ate the roasted crown (Medsger 1938). The croziers, or fiddleheads, have been eaten as a spring vegetable by European colonists in New Brunswick since 1784 (Fisher 1825), and later, in the New England area. According to Gams (1938) the Norwegians used the Ostrich Fern in the making of beer. This species has been listed as a vermifuge in Russia (Komarov 1934). In eastern North America, fresh fiddleheads are a spring market vegetable. Canned and, more recently frozen fiddleheads have become available throughout the year. The tonnage of fiddleheads harvested increased greatly with the sale of the frozen product (von Aderkas 1984b).

M. struthiopteris fiddleheads are neither toxic nor carcinogenic as shown in laboratory studies on rats (Newberne 1976). They are an excellent source of nutrition (Bushway et al. 1982). A 100 g portion of wet fiddlehead greens will furnish 25, 13, 2, 46 and 71% of the U.S. Recommended Dietary Allowance (RDA) for niacin, riboflavin, thiamin, vitamin C and vitamin A, respectively. The percent RDA of the mineral elements supplied by a 100 g serving of fiddleheads would be 4% calcium, 10% magnesium, 13% phosphorus, 11% iron and 4% zinc. The fibre content represents a substantial proportion of the solids content, and could contribute to dietary fibre intake. Because of their low sodium content (0.5 mg/100 g) Ostrich Fern fiddleheads are suitable for salt-restricted diets. The fiddleheads are comparable in nutritional quality to many common green vegetables.

Gellerman et al. (1972) report the occurrence of arachidonic acid and 5,8,11,14,17-eicosapentaenoic acids in *M. struthiopteris.* These highly unsaturated fatty acids, although required by higher animals, are not synthe-

sized by them except when appropriate precursors are provided in the food. These acids are not found in seed plants, but occur in lower plants. Arachidonic acid is found in all sporophyte tissues at levels of 5.8–9.8%.

Recently there has been interest in both management of wild Ostrich Fern populations (Roberts-Pichette 1971; Dykeman 1982a) and field cultivation (Dykeman 1981, 1982b). Research on *M. struthiopteris* has been coordinated by the Atlantic Fiddlehead Research Organization.

Acknowledgments

Financial support for this research was provided by the National Research Council, Nova Scotia Department of Agriculture and Marketing Research Committee, and Natural Sciences and Engineering Research Council operating grant A8342.

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Received 16 August 1983
Accepted 11 September 1984

Notes

Range Extension of the American Wigeon, *Anas americana*, to the Island of Newfoundland

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Goudie, R. Ian. 1985. Range extension of the American Wigeon, *Anas americana*, to the island of Newfoundland. Canadian Field-Naturalist 99(4): 533.

Three flightless juvenile American Wigeon (*Anas americana*) banded in early August 1979 at Codroy delta in southwestern Newfoundland represent the first breeding record for the island. This record helps document the northeastward range extension of this species noted by other authors.

Key Words: American Wigeon, *Anas americana*, Newfoundland.

Since 1978 the Canadian Wildlife Service has studied waterfowl diversity and distribution in insular Newfoundland to provide input for the management of waterfowl in the Atlantic Flyway. During this study an extension of the breeding range for the American Wigeon (*Anas americana*) was noted.

American wigeons have been observed infrequently in Newfoundland over the past three decades [see Lamberton, 1976. Avifaunal Survey of Gros Morne National Park. Parks Canada Ms., unpublished; Peters and Burleigh (1951); Tuck and Borotra (1972)]. Numbers of American Wigeons have increased significantly in the east since 1950 (Palmer 1976), and this species has become established throughout the maritime provinces since 1957 (Godfrey 1966).

On 5 July 1979 in the Grand Codroy River delta (47° 50′N, 59° 10′W), A.J. Erskine and I encountered groups of unpaired American Wigeons and one female feigning a broken wing. Subsequently in early August the author was involved in the banding of three flightless local American Wigeon ducklings there. This is the first confirmed breeding record of American Wigeon for insular Newfoundland. Canadian Wildlife Service captured and banded 11 ducklings, of at least three different broods, 3 August 1980, and 16 ducklings of at least six broods on 2 August 1981.

Many waterfowl species appear to be expanding eastward, apparently in response to post-glacial climate and habitat changes (Palmer 1976). Apparent preferred breeding habitat of floating and submergent vegetation and dry *Carex* meadows (Johnsgard 1975) is of frequent occurrence in Newfoundland. It is likely the American Wigeon will continue to expand its breeding range on the island of Newfoundland.

Acknowledgments

The assistance of Eric Chaytor, A.J. Erskine, R.D. Elliot and Roger Etcheberry in the field, in discussion of records or criticisms of earlier drafts, is greatly appreciated.

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Received 4 June 1984
Accepted 25 September 1984

A Note on "Condominium" Nesting of the Northern Flicker, *Colaptes auratus*, in Western Alberta

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Salt, Jim R. 1985. A note on "condominium" nesting of the Northern Flicker, *Colaptes auratus*, in western Alberta. Canadian Field-Naturalist 99(4): 534–535.

Two pairs of Northern Flickers (*Colaptes auratus*) were found to be nesting in the same tree near Hinton, Alberta. Such "condominium" nesting is infrequently reported in flickers, though unorthodox nesting sites are well documented. There appear to be no other records of group nesting in flickers in western Canada.

Key Words: Northern Flickers, *Colaptes auratus*, western Alberta, shared nesting site.

In an area 12–18 km west of Hinton, Alberta, 2 July 1983, Jason and Susan Maitland and I discovered two nests of Northern Flicker, (*Colaptes auratus*), at the south edge of a small clone of Aspen (*Populus tremuloides*) in a region of extensive upland conifer and mixed woods separated by spruce/tamarack (*Picea* and *Larix*) bogs and isolated montane slopes. The two active nests were situated in the same tree, 43 cm apart, the lower hole about 1.8 m above ground. J. Maitland photographed the birds, and noted three adult flickers present simultaneously around the nest-holes. Further observation from a short distance proved that two pair of flickers did indeed share this nest-site. The lower hole, facing south, contained three large young; the upper one faced west-southwest, with at least two young. We noted also a pair of Hairy Woodpeckers, *Picoides villosus*, tending a nest containing three young, less than 12 m away from that of the flickers, in a similar location.

Reports of two or more pairs of flickers "condominium" nesting are infrequent. In South Carolina, a stump 6 m (20 ft.) in height contained not only two active flicker nests, but also "one each of screech owl, crested flycatcher and downy woodpecker" (Sprunt 1931). Hollister (1918) found a flicker sharing a nest-tree with House Wrens (*Troglodytes aedon*) in Washington. Burns (1900) and Bent (1939) both cite occurrences of flicker eggs in the same nest cavities with those of one or more other species: Tree Swallow (*Tachycineta bicolor*), bluebird (*Sialia* sp.), Red-headed Woodpecker (*Melanerpes erythrocephalus*).

The unorthodox nature of the flicker's nesting habits is well documented. Nests have been located on the ground in open sand and in hay-stacks (Bent 1939). Allen (1872), Peck (1911), Bailey and Niedrach (1965), Verbeek (1974), and others have noted flicker nests in clay banks; Bradshaw (1930) and Porter (1932) found bank nests in southern Saskatchewan.

I have seen no mention of shared or group nesting in the literature for western Canada. It is not clear, in the many accounts cited, whether the flickers acted in response to a lack of suitable nest trees, although several observers mentioned that other, apparently adequate, nest-trees were noted in the immediate vicinity. At the Hinton nest-site, there was no evidence of a lack of suitable nest sites. The grove was roughly 1 ha in area, cut through by a gravel road so as to expose many of the tallest aspen (6–10 m), a number of which seemed identical to the nest tree in aspect and condition. The site was divided from a fen of *Salix, Betula, Picea* and *Larix*, about 120 m to the south, by a narrow stand of Balsam Poplar (*P. balsamifera*), which appeared uninhabited by breeding woodpeckers. The mixed woods on that south-facing slope covered many hectares, with groves of aspen scattered throughout. Although a clear preference was demonstrated for this nest-tree, no reasons for the preference were evident.

Erskine and McLaren (1972), in their work on Yellow-bellied Sapsucker (*Sphyrapicus varius*) nest habits in the British Columbia interior, provided some interesting comparisons between nesting habits of flickers and those of sapsuckers. The authors remark that the "tenement" trees of sapsuckers quite commonly had five or more holes, but that flickers on the other hand seemed reluctant to make new nest-holes. My own observations of the latter species in central and western Alberta support those of many of the observers cited here, indicating that the birds much prefer to seek out existing cavities each spring. Early banding recoveries in the Canadian prairies showed that flickers generally returned to the same nest-site or natal territory annually (Bent 1939, p. 263), a habit which would encourage intra-specific competition, particularly in years immediately following a summer of high productivity.

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Received 21 March 1984
Accepted 15 October 1984

Mineralization of Subcutaneous Tissue in Beaver, *Castor canadensis*

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Gainer, Robert, and Kirby Smith. 1985. Mineralization of subcutaneous tissue in Beaver, *Castor canadensis*. Canadian Field-Naturalist 99(4): 535–536.

A calcified mesh-like layer was found in the subcutis of two Beaver kits, *Castor canadensis*. This condition has not previously been described for this species and only partially resembles soft tissue mineralization in other species.

Key Words: Beaver, *Castor canadensis,* pathology, subcutis, mineralization.

During spring break-up in the Central Alberta foothills, a local trapper shot two yearling Beaver kits that were lethargic and easily approached. When skinning them, he noticed their hides peeled off with relatively little effort. Normally, Beaver have an extremely thick and fibrous subcutaneous tissue that required much stretching and slicing to remove their hides. The trapper also thought that their limbs and tails were thicker and more flexible than normal.

On examination of the hides, the subcutaneous surface of both had a white 0.5–2 mm thick, mesh-like layer of a stiff and fibrous material that covered most of the anterior dorsal portions of the hides. Both animals were emaciated, with no gastro-intestinal contents. Microscopically the mesh-like layer of skin was found to have a heavy and extensive mineralization of the dermal collagen fibres.

The literature of Beaver pathology is quite limited and its review does not reveal a description of such a condition. Dietrich (1969) described soft tissue calcification in captive beaver involving mesenteric blood vessels, bronchi and kidneys. He thought it was secondary to interstitial nephritis and the disturbance to mineral metabolism associated with it. Unfortunately the material submitted by the trapper was not suitable for kidney examination although a focal necrosis was noticed in the lungs of one kit.

Jubb and Kennedy (1963) describe a condition in the subcutis of young dogs, calcinosis circumscripta or calcium gout. Lesions are more localized than a mesh-like layer however, and the thickening of the limbs is hard rather than the softening described by the trapper.

Enzootic calcinosis is a widespread condition of ruminants and horses (Blood et al. 1983) in which extensive metastatic mineralization of soft tissue occurs. Known causes fall into two categories; plant poisonings that upset mineral metabolism and mineral imbalances in the soil.

The pond from which the kits were taken had a cloudy effluent draining from a field of exposed limestone and gypsum suggesting high levels of calcium in

the environment. However water samples were within normal ranges for alpine streams. Little can be said about the vegetation other than it is slightly more alpine than is normally associated with Beaver.

Acknowledgment

We wish to thank Dr. R. Lewis for his assistance with the histopathology.

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Received 13 April 1984
Accepted 26 October 1984

Hairy Hawkbit, *Leontodon taraxacoides*, in Central Canada

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Morton, J. K. 1985. Hairy Hawkbit, *Leontodon taraxacoides*, in central Canada. Canadian Field-Naturalist 99(4): 536–538.

The Hairy Hawkbit (*Leontodon taraxacoides* subsp. *taraxacoides*) is reported from three stations in Ontario where it is growing as a weed in lawns and on roadside verges. An earlier record of this species from Ontario, based on a collection made in Galt in 1902, is referable to *L. hispidus*.

Key Words: *Leontodon taraxacoides*, Hairy Hawkbit, flora of Ontario.

The Hairy Hawkbit (*Leontodon taraxacoides* (Vill.) Mérat subsp. *taraxacoides* L. nudicaulis subsp. taraxacoides (Vill.) Schinz & Thell.) was recently found growing in abundance on Manitoulin Island. Its discovery prompted me to investigate the known occurrence of this small dandelion-like alien in Canada, and particularly an early report (Montgomery 1948) of the species from Ontario.

Unlike the other species of Hawkbit (*Leontodon*) and Cat's-ear (*Hypochoeris*), which have been introduced into this continent, the Hairy Hawkbit (Figure 1) has its flower heads carried on very slender stems. These are unbranched, about 10 to 20 cm high and several arise from a rosette of dandelion-like leaves. Leaves and stems have scattered long spreading soft hairs. Besides its slender habit the distinguishing feature of the Hairy Hawkbit lies in the structure of the outermost row of fruits. These differ from the inner ones in having a ring of thin papery scales around the top, instead of the usual feathery hairs.

The Hairy Hawkbit has had many name changes during the past century and reference to it will be found in both European and North American floras under *Thrincia hirta, Leontodon Leysseri, L. nudicaulis* and *L. hirtus*. Current taxonomic and nomenclatural opinion (Tutin et al. 1976) applies the name *L. taraxacoides* (Vill.) Mérat to this plant. Our material belongs to the type subspecies, which is the only subspecies known to occur in North America.

The Hairy Hawkbit has been reported from widely scattered localities in the United States (Fernald 1950; USDA 1982). In Canada it has been known from Vancouver Island, particularly in and around Victoria, for many years. The only other Canadian record appears to be that of Montgomery (1948) who reported the plant from Galt, Ontario. However, the record is questioned by both Boivin (1966) and Scoggan (1979). Montgomery cites Herriot (1910) as the basis for his record but reference to that work indicates that the only *Leontodon* listed is *L. hispidus*. Examination of the specimen on which the record is based (Herriot 2 from Galt dated 14/6/1902 in OAC) shows that it was and is correctly identified as that species.

A search for other collections of this plant (the following herbaia was checked: CAN, DAO, MT, OAC, SLU, TRT, TRTE & WAT) has revealed two further localities for it in Ontario, besides the recently discovered Manitoulin station. These are at Bala and Victoria Harbour in the cottage country on the east

FIGURE 1. The Hairy Hawkbit (*Leontodon taraxacoides*) from a specimen collected on Manitoulin Island. Scale ×⅔

side of Georgian Bay. In all three localities the Hairy Hawkbit is a weed in lawns or on nearby roadside grass verges. The relevant voucher collections supporting these records for the occurrence in Ontario of this interesting alien weed are: —

J. K. Morton NA 15392 (JKM, DAO, MICH) lawns and roadside verges in Silver Water, Manitoulin Is. 1/10/1983.

Whiting & Goltz 2441 (TRT) lawn weed, Bala, Medora Twp. Ontario 12/10/1975.

Reznicek & Bobbette 3865 (TRT) lawn weed, Victoria Harbour, Simcoe Co. Ontario 1/9/1973.

In Europe, where the Hairy Hawkbit is native, it grows in dry grassy, often sandy situations. However, in North America it tends to be a weed in dry disturbed ground along roadsides and in lawns.

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Received 5 April 1984
Accepted 29 August 1984

Addendum: Since this manuscript was accepted for publication the Hairy Hawkbit has been found on the outskirts of Waterloo, Ontario, (Clark 13 in WAT: growing in a lawn at Green Acres Trailer Park, Beaver Creek Road, Waterloo. 15/9/1984).

Early Records of the Channel Catfish, *Ictalurus punctatus*, in Cumberland Lake, Saskatchewan

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Atton, F. M. 1985. Early records of the Channel Catfish, *Ictalurus punctatus*, in Cumberland Lake, Saskatchewan. Canadian Field-Naturalist 99(4): 538–540.

A record and description of a channel catfish (*Ictalurus punctatus*) is reported for Cumberland Lake, Saskatchewan in 1797. This gives credibility to the record of Richardson (1836) which has sometimes been questioned, and extends the accepted former range of this species in western Canada.

The record and description of a Channel Catfish by Sir John Richardson from Pine-Island Lake (= Cumberland Lake), where it was apparently obtained in 1820 (Richardson 1836), has been a problem for ichthyologists (Scott and Crossman 1979; Willock 1969). The species has not been recorded since that time in the Saskatchewan system, nor nearer than the northern end of Lake Winnipegosis (Scott and Crossman 1979, page XVII). His description is certainly that of a Channel Catfish. He also indicates the species was well enough known to be a preferred item of diet over the Walleye (Richardson 1836, p. 15); this is internal evidence that the species was independently recognized by local fishermen. It has been speculated that either Richardson's identification of the specimen was wrong or that his locality was wrong.

Recently I found external evidence in an earlier record of a catfish from Cumberland Lake. This is in the Cumberland House Journal by Peter Fidler (1797), 8 November 1797. Fidler was a surveyor for the Hudson's Bay Company who was in charge of Cumberland House during three years at this time. He wrote:

> "Nov. 8 Wednesday — Sent 2 men with a tent to stay by the nets to overhaul them — also 4 men went and looked at 7 nets and got 43 sturgeon (28 of which they brought home) and one Cat Fish which weighed 12¾ lb. This is the first fish of the kind I have ever seen — now and then I is caught mostly every winter here as I am told. The head is flattish, broad and chubby, with a wide mouth like a frog's — on each corner of the mouth a sort of thread of ¼ inch diameter and 4 inches long, also on the upper part of the head near the extremity of the nose are 2 smaller thread of about 1 inch long and 4 of the same kind of thread on the under jaw near the extremity. The 2 outer ones are the longest and the other 2 in the middle are about 1 inch long, rather longer than the 2 on the upper side of the head. The eyes are 4½ inch apart and placed on the 2 opposite sides. The socket of the eye about ¾ inch diameter. Thick lips and a great number of small teeth scarely denumable. It had 4 fins on the belly — 2 pectoral and 2 ventral and a large anal fin — upon the back also a fin of the same size as one of the ventral's and nearer the tail, one rather smaller and a forked tail. The back is of a dark dun color, and the belly of a reddish one — along the sides a few small blackish spots interspers'd here and there. The fish measured 2 feet 7 inches long. I believe it is a non discript.
>
> Three nets they did not overhaul as they

could not bring all the fish home with them. The other people as yesterday. Fresh gales at WSW, cloudy and clear alternate — severe weather for the season."

This is an excellent description of a catfish. It mentions especially eight barbels, the shape of the head, small blackish spots on the sides, and the forked tail. He also says that this species ("kind") is recognized by the employees who had previously wintered at Cumberland House. The forked tail and eight barbels confirm the species, since in Canada only the channel catfish has this combination of characters. The only catfish that reaches 787 mm. is the channel catfish, the maximum for the black bullhead being 610 mm for the brown bullhead being 532 mm.

It is not clear what Fidler meant by the term "non discript"; it is clear he expected his readers to understand without difficulty. In the 18th century usage the term was regularly equivalent to our modern use of "new species" (e.g. Edwards 1750, p. 107, 114). The Oxford English Dictionary gives nondescript as meaning not yet described, in natural history. I am of the opinion that Fidler recognized he had an undescribed species, and designated it thus. This explains his careful description of what he considered an unclassified fish.

This record of the Channel Catfish in Cumberland Lake provides the evidence to give full credibility to Richardson's specimen of 23 years later. Richardson neither reported a wrong identification nor recorded a wrong locality.

A comparison of the available measurements on these two specimens with the most recent record (Dean 1983) is shown in Table 1. The measurements are on fresh specimens, not comparable with preserved material. The length given by Richardson "exclusive of the caudal" cannot be understood as total length. It is probably neither standard length nor fork length, but measured to the obvious base of the musculature, between these two measurements. The numbers in brackets are calculated on this assumption. Richardson's specimen is the largest, but not outsized compared with the others. Data on a preserved specimen from a Thames River tributary in Ontario are also given.

Fidler's description of the Channel Catfish appears to be the earliest known, since it is 21 years before that of Rafinesque (1818). It could not however, be considered to have nomenclatural priority over the latter, because it was not published and Fidler did not designate it except by its Cree name, mathemeg. It seems likely that Richardson was not in any way aware of this earlier description, since in 1836 he had lost his own specimen, and would have been anxious to compare his notes with another description.

Richardson knew the correct Cree name for the fish he saw at Cumberland House because it was familiar to Hudson's Bay Company employees. The only error he made was to equate his specimen with the erroneus use of the same name by Pennant (Speirs 1952) for a different fish, the Burbot (*Lota lota*).

These Saskatchewan records alter the map of former distribution of this species (Glodek 1979) to include Saskatchewan drainage basin waters as far as Cumberland Lake as well as the Assiniboine-Qu'Appelle waters in eastern Saskatchewan. Fidler's independent description is the earliest catfish species record for western Canada. There is a new problem raised, however. Why has the range of the channel catfish receded southward since some time after about 1830?

Acknowledgments

I am particularly indebted to the Hudson's Bay Company Archives, Provincial Archives of Manitoba, Winnipeg, for making available the quotation

TABLE 1. Comparison of three Saskatchewan specimens of the Channel Catfish, and one preserved specimen from Ontario. All measurements are in mm, except weight in kg.

	Fidler 1797	Richardson 1820	Dean 1983	NMC 60-523A
Standard length	(683)	(727)	625	382
"Exclusive of caudal"		762	(655)	385
Fork length	(749)	(796)	685	419
Total length	787	(838)	720	464
Maxillary barbel	101.6			87.8
Nasal barbel	25.4	25.4		21.8
Outer lower jaw barbel	25.4+	63.5		50.5
Interorbital width	114.3			53.2
Orbit diameter	19.0			12.5
Weight kg	5.8	(6.3)	5.6	

Data on the preserved specimen (NMC 60-523A) was kindly suplied by D. E. McAllister, Curator of Fishes, National Museums of Canada, Ottawa.

from the 1797 Cumberland House Journal. C. S. Houston, D. E. McAllister and C. C. Lindsey made very useful comments.

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Received 3 April 1984
Accepted 3 October 1984

Further Evidence of the Encroachment of the Threespine Stickleback, *Gasterosteus aculeatus*, into the Upper Great Lakes

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Fleischer, Guy W., and Dan C. Brazo. 1985. Further evidence of the encroachment of the Threespine Stickleback, *Gasterosteus aculeatus*, into the upper Great Lakes. Canadian Field-Naturalist 99(4): 540–541.

Seven Threespine Sticklebacks, *Gasterosteus aculeatus*, were collected in the St. Marys River drainage, Chippewa County, Michigan (46° 11′N, 84°07′W). This represents a 190 km extension beyond previous records.

Key Words: Threespine Stickleback, *Gasterosteus aculeatus*, range extension, St. Marys River, intermediate form.

The Threespine Stickleback, *Gasterosteus aculeatus*, is a Holarctic fish with both fresh and saltwater populations; some populations remain in freshwater throughout their lives, whereas those spending their adult life in saltwater may migrate into freshwater only to spawn (Scott and Crossman 1973). Threespine Sticklebacks occur indigenously throughout Europe and the coastal regions of Asia, Iceland, Greenland and North America. Up to 1980 the recorded range of the Threespine Stickleback did not include the Great Lakes above Niagara Falls (E. J. Crossman, personal communications, 1982). In June 1980, eleven specimens were collected at the Ontario Ministry of Natural Resources South Baymouth Fisheries Research Station, Manitoulin Island, Lake Huron. This was documented and confirmed as a range extension of 300 km (Gibson 1982).

During fish collections as part of an ongoing study to provide baseline data for the St. Marys River (46° 11′N, 84°07′W) by Michigan State University (Liston et al. 1983. ms*), we collected seven Threespine Sticklebacks in 1982 and 1983. All specimens were captured with trap nets, constructed of 6.35-mm bar mesh nylon having a 15.2 × 1-m lead, 7.2 × 1-m wings, a 1-m² pot and a single heart, in nearshore areas at a maximum depth of one meter.

During the week of 7 June 1982, the first Threespine Stickleback was collected and a second fish was captured in July. In spring and summer of 1983, an additional five specimens were collected. In 1982, another specimen was captured above the St. Marys rapids at the outflow of Lake Superior but was not included in this report.

At time of capture, total length, sex and gonadal

*Unpublished report: see Acknowledgments

condition were recorded for each specimen. All fish were labeled and preserved for further analysis and are stored at the Michigan State University Great Lakes Research Laboratory, Ludington, Michigan. Lateral plate and gill raker enumerations, diagnostic characteristics established by Hagen (1967) to distinguish between marine (*trachurus*) and freshwater (*leiurus*) morphs were made. Any individual with intergrade characteristics between the two morphs was classified an intermediate form.

All Threespine Sticklebacks were adults (2 males, 5 females) in prespawning condition (i.e., well developed gonads), from 42 to 54-mm TL, suggesting their third summer of growth (Jones and Hynes 1950). Gill raker and lateral plate counts ranged from 15–17 and 23–26, respectively. These values were characteristic of an intermediate form which Hagen (1967) suggested may be observed in freshwater progeny of *trachurus* parents. However, the fish taken in the St. Marys River were fully-plated from anterior through keel suggesting the marine morph. Gibson (1982) reported the *trachurus* form from Manitoulin Island, Lake Huron, and Stedman (personal communication, 1984) also collected the *trachurus* morph from northern Lake Huron.

The presence of the Threespine Stickleback in the St. Marys River represents a 190 km extension beyond Manitoulin Island, Lake Huron. However, more recent information indicates Threespine Sticklebacks are present throughout northern Lake Huron (R. Stedman, personal communication, 1984). It is premature to suggest their establishment in the St. Marys River since no larvae or juveniles were collected nor any adults past their spring-summer spawning period.

Acknowledgments

These records were possible through support to the following baseline study: Liston, C., C. McNabb, W. Duffy, D. Ashton, R. Ligman, F. Koehler, J. Bohr, G. Fleischer, J. Schuette, and R. Yanusz. 1983. Environmental baseline studies of the St. Marys River near Neebish Island, Michigan, prior to proposed extension of the navigation season. Michigan State University, Department of Fisheries and Wildlife report to U.S. Fish and Wildlife Service, Contract No. 14-16-0009-79-013.

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Received 31 July 1984
Accepted 18 October 1984

Northern Range Extension of the Echeneidid Fish *Remora remora* in the Northeastern Pacific Ocean During a Year of El Niño

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Hughes, Grant W. 1985. Northern range extension of the echeneidid fish *Remora remora* in the northeastern Pacific Ocean during a year of El Niño Canadian Field-Naturalist 99(4): 541–542.

A specimen of the Remora (*Remora remora*) was captured 4 August 1983 in a surface gill net approximately 800 km west of Cape Shoalwater, Washington (46°42.8′ N, 131°25.0′ W). This 1000 km northern range extension may have been facilitated by the El Niño phenomenon in 1982-83.

Key Words: *Remora remora*, Washington, Pacific Ocean, distribution, El Niño.

El Niño is a phenomenon characterized by unusually warm surface waters along the coastal zone of South America and most of the tropical Pacific Ocean (Philander 1983). A 1982-83 El Niño may have contributed to a more northerly distribution of some warm-water fishes in the northeastern Pacific Ocean,

resulting in extensions of known ranges to include British Columbia waters (examples in Peden and Hughes 1984).

It is noteworthy to report a 1000 km extension of the known range of the Remora (*Remora remora*) in the northeastern Pacific Ocean to a position approximately 800 km west of Cape Shoalwater, Washington (46°42.8′N, 131°25.0′W). The specimen was captured on 4 August 1983 in a surface gill net (British Columbia Provincial Museum catalogue number BCPM 983–1711). *R. remora* has been previously recorded from San Francisco, California to Chile along the Pacific coast of the Americas and world wide in warm seas (Eschmeyer et al. 1983).

The 180 mm standard length specimen was diagnosed by its uniform brown colouration, a small disk with posterior margin anterior to tip of pectoral fin, 17 laminae, 26 dorsal fin rays, 23 anal fin rays, 28 pectoral fin rays, and 27 vertebrae (see Maul 1945; Miller and Lea 1972; Eschmeyer et al. 1983). Radiographs were prepared and fin and vertebrae counts followed techniques given by Hubbs and Lagler (1958).

The specimen was collected and donated to the British Columbia Provincial Museum through the courtesy of S. Robinson of the Pacific Biological Station, Nanaimo, British Columbia.

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Received 25 June 1984
Accepted 18 September 1984

Man-caused Deaths of Mountain Caribou, *Rangifer tarandus*, in Southeastern British Columbia

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Johnson, Donald R. 1985. Man-caused deaths of mountain Caribou, *Rangifer tarandus*, in southeastern British Columbia. Canadian Field-Naturalist 99(4): 542–544.

Although protected by law, hunter kills accounted for 13 recorded deaths of Caribou (*Rangifer tarandus*) in the southern Selkirk Mountains of southeastern British Columbia between 1967 and 1983. Seven additional deaths resulted from collisions with motor vehicles on Highway 3 since opening of the Creston-Salmo section in 1963. There were eight recorded hunter kills of Caribou in the southern Purcell Mountains since the season was closed in 1972. Man-caused deaths could have equalled recruitment within the Selkirk population during several years between 1972 and 1983.

Key Words: Caribou, *Rangifer tarandus*, mortality, recruitment, overhunting.

Bergerud (1974) has presented convincing evidence that overhunting, sometimes in conjunction with predation, has been the primary cause of the decline in Caribou populations on this continent since settlement by Europeans. Since Wolves (*Canis lupus*) occur at low densities in southern British Columbia (Bergerud 1983), man-caused deaths alone can be expected to account for most of the losses in this region.

Methods

I have maintained a record (date, sex, age, location) of Caribou deaths in the Selkirk and Purcell Mountains since 1974. Earlier records of deaths in these populations were secured from the literature (Freddy 1974) and from correspondence with British Columbia Wildlife Branch personnel. Assuming growth rates similar to those of the Kaminuriak population (Miller 1974), I utilized mandible length and the

TABLE 1. Man-caused Mortality of Caribou, Southeastern British Columbia, 1967–83. SM = Selkirk Mountains; PC = Purcell Mountains; BCPM = B.C. Provincial Museum; UI = University of Idaho; SC = Selkirk College; unk = unknown; ad = adult; im = immature. Multiple kills are recorded under a single date.

Date	Sex	Age (yrs)	Cause	Location	Comments
March 1967	m	< 1	collision	Salmo Summit, SM	Layser (1974:30)
October 1967	f	7	shot	Salmo Summit, SM	Skull BCPM
	m	2+	shot		Skull BCPM
October 1971	m	im	shot	B.C. Highway 3, SM	Freddy (1974)
November 1971	f	< 1	collision	B.C. Highway 3, SM	Freddy (1974)
November 1971	unk	ad	shot	Salmo Summit, SM	Skull UI
	unk	ad	shot		Skull UI
	unk	ad	shot		Skull SC
October 1972	m	7–9	shot	Salmo Summit, SM	Freddy (1974)
November 1972	m	ad	shot	Elmo Creek, SM	Freddy (1974)
November 1974	f	ad	shot	Crawford Creek, PM	Carcass seized
July 1976	unk	< 1	collision	N. Fk. Summit Ck. SM	Unconfirmed report
October 1976	f	ad	collision	N. Fk. Summit Ck. SM	Skull, hide UI
September 1977	m	2+	shot	Salmo Summit, SM	Skull, hide UI
November 1978	m	ad	shot	Crawford Creek, PM	Carcasses seized
	m	ad	shot		
October 1980	m	ad	destroyed	Arkansas Lake, SM	Head Mount UI
January 1982	m	2+	destroyed	Summit Creek, SM	Skull BCPM
September 1982	m	im	shot	Skelly Creek, PM	Carcass seized
October 1982	f	unk	shot	Carolina Creek, SM	Skeleton BCPM
October 1983	m	2+	shot	Waldie Lake, SM	M. Scott (in litt.)
October 1983	f	ad	shot	Kamma Creek, PM	Skull UI
	f	ad	shot		Skull UI
	f	< 1	shot		Skull UI
October 1983	m	ad	shot	Kamma Creek, PM	Antlers seized

sequence of molar eruption to determine sex and age when these were otherwise unknown. In some instances, counts of cementum annuli were used as an additional means of age determination. Because of similarities between the sexes, the size and shape of the antlers could not be used to identify the sex of immature animals (Fuller and Keith 1980).

Results

Illegal hunting, accounted for 75% of the recorded deaths within these populations since 1967 (Table 1). All hunter-caused mortality occurred during the fall months (September through November). A large bull, found near Arkansas Lake in October 1980, had received a gunshot wound in the head which broke its lower jaw. The right forefoot of a young bull, found in the Summit Creek basin in January, 1982, had been amputated at the metacarpus, perhaps as a result of a gunshot wound. Both animals were destroyed by conservation officers.

Of the 28 deaths recorded, 13 were males, 8 were females and 4 were of unknown sex (Table 1 plus 3 undated collision-caused deaths). With respect to age, 10 of the deaths were less than 3 years old and 15 were adult animals 3 or more years old. Earlier I suggested (Johnson 1976) that collision with motor vehicles along B.C. Highway 3 represents a major threat to the Selkirk population. While that threat remains, there has been no recorded occurrence of a collision-death since 1976 (Johnson and Todd 1977). The use of warning signs in the vicinity of the Salmo Summit in recent years may have been effective in reducing such mortalities.

Discussion

These data undoubtedly underestimate the level of man-caused death because of the low probability of confirming it. Poaching continues despite a closed season in the Selkirk Mountains since 1957 (Flinn 1959) and the Purcell Mountains since 1972. The number shot by hunters who confuse them with other large game species is unknown. The decision by the B.C. Wildlife Branch to close all hunting in certain areas of the Selkirk Mountains receiving heavy Caribou use reduces the threat of inadvertent poaching, at least locally.

Confirmed man-caused deaths accounted for at least 21% of the potential recruitment of the Selkirk population where calf production from 1972 through 1983 has averaged 3.6 annually (Johnson and Miller

1979; unpublished data). With the additional number which go undetected, man-caused deaths could have equalled recruitment during several years within this period.

Although predation has been discounted as a major cause of deaths in the Selkirk population (Freddy 1974), there is some possibility that bears take neonates. Both Black (*Ursus americanus*) and Grizzly bears (*U. arctos*) occur within the range of these Caribou.

The continued development of road systems has provided ready access for hunters. Bergerud (1979) has described the precipitous decline of several Caribou populations in northern British Columbia following the improvement of access into their ranges. He identifies access as the greatest threat to caribou. Limiting road access, strict law enforcement and closure to all hunting of areas receiving heavy caribou use are management options which offer opportunities to reduce man-caused mortality in these Caribou populations.

Acknowledgments

I thank David Gray and Richard Hoar, British Columbia Wildlife Branch, who provided most of the information on man-caused deaths reported here. Michael Scott, Idaho Fish and Game Department, improved the accuracy of recent reports. Patricia Wakkinen, Idaho Fish and Game Department, stained and sectioned incisors for annuli counts. David Nagorsen, Curator of Mammals, British Columbia Provincial Museum, provided data from specimens in his care.

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Received 20 March 1984
Accepted 29 August 1984

Long-term Retention of Floy Tags by Arctic Grayling, *Thymallus arcticus*

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Kratt, L. F. 1985. Long-term retention of Floy tags by Arctic Grayling, *Thymallus arcticus*. Canadian Field-Naturalist 99(4): 545–546.

Arctic Grayling (*Thymallus arcticus*) have retained Floy FD–68B T-bar internal anchor tags for a period of nearly 10 years. Recently recaptured Grayling are likely in the range of 11 to 13 years old.

Key Words: Arctic Grayling, *Thymallus arcticus*, tags, tagging, loss, retention, Saskatchewan

Tagging has proven to be a useful technique in studies of the biology and management of fish populations and numerous types of tags have been developed to meet the needs of fisheries workers. To be useful tags should be easily and rapidly applied, have an insignificant effect on growth and mortality, be readily recognizable and contain sufficient instructions for persons likely to capture marked fish. It is also very important that the tag not be shed or deteriorate with time.

Numerous reports have been published on the general topic of tagging and several papers address the question of tag retention (for example, Armstrong and Blackett 1966; Rawstron 1973; Wilbur and Duchrow 1973; Greenland and Bryan 1974; Ebener and Copes 1982). In most instances these reports document the rate of tag loss over relatively short periods of time. There are few published records of long-term retention of tags.

This paper documents the retention of Floy FD–68B[1] T-bar internal anchor tags by Arctic Grayling (*Thymallus arcticus*) for a period of nearly 10 years. The data provided do not allow for any analyses of the significance of the observed results. However, the observations reported here are of interest and do give some indication of the usefulness of these tags.

Methods

In 1973 and 1974 Arctic Grayling were collected in the portion of the Fond du Lac River situated between Black Lake and Middle Lake in northern Saskatchewan (59° 05′N, 105° 33′W). Numbered Floy FD–68B anchor tags were attached below the base of the dorsal fin on the upper left side of each fish using a gun-type applicator (Dell 1968).

Tagging was conducted in two separate areas of the river as the purpose of the study was to examine movements of Grayling between the two lakes and to determine whether a natural barrier, Elizabeth Falls, completely blocked migrations between the upper and lower reaches. Orange tags were utilized upstream of the falls and yellow tags downstream.

[1]Use of trade names does not constitute endorsement of the product.

Results and Discussion

Numerous tags were returned by anglers during the 1974 intensive study period (Envirocon Ltd., unpublished report) with lesser numbers being reported between 1975 and 1978 (Kratt 1977; Saskatchewan Environment, unpublished data).

On 27 June 1982, a tagged Grayling was caught near the outlet of Black Lake. That fish had been tagged in the same general area on 19 May 1974. Another tagged Arctic Grayling was caught in July 1983, near the inlet to Middle Lake. Exact tagging information is not available but a check of the tag number revealed that this fish had been tagged in the same region some time between 21 and 27 September 1973. These individuals had therefore retained their tags for 8 years, 1 month and 9 years, 10 months, respectively.

No attempts were made during the Fond du Lac River study to document the rate of, or reasons for, tag loss from Arctic Grayling. Highly variable rates of shedding have been reported for Floy internal anchor tags. For example, Wilbur and Duchrow (1973) reported 53 per cent, 25 per cent and 12 per cent loss for tag types FD–67C, FD–67 and FD–68B, respectively, on Largemouth Bass (*Micropterus salmoides*) after 97 days. However, Stobo (1972) observed no loss of FD-67 tags on Yellow Perch (*Perca flavescens*) after 3.5 months. Ebener and Copes (1982) estimated the loss of FD–68C tags from Lake Whitefish (*Coregonus clupeaformis*) at 11.1 per cent for fish at large for 1 year to 20.5, 18.9 and 14.3 per cent after 2, 3 and 4 years, respectively. Unfortunately, studies related to tag loss are generally of a short-term nature and information on anchor tag retention beyond 4 or 5 years is lacking.

Improper engagement of the T-bar behind the interneural bones has been cited most frequently as the reason for loss of internal anchor tags. Other possible factors affecting retention include entanglement of the tag in vegetation or gillnets, the attack of fish on each others' tags, or the growth of filamentous algae causing irritation or increasing the drag of the device (Carline and Brynildson 1972; Wilbur and Duchrow 1973; Greenland and Bryan 1974; Ebener and Copes 1982).

Chadwick (1963) and Hedgepeth et al. (1978) reported that the inscription on Floy tags deteriorated over time. Such has not been the case for tags returned during this study.

Also of interest is the age of the recently caught tagged Grayling. Most fish tagged during the study were 3 or 4 years old, although a few fish as young as age 1 were marked (Envirocon Ltd., unpublished report; personal observations). The two individuals in question are therefore likely in the range of 11 to 13 years old. Grayling in this area rarely reach age 10 (Saskatchewan Parks and Renewable Resources and Saskatchewan Environment, unpublished data) and during the Elizabeth Falls study no fish older than age 7 was collected (Envirocon Ltd., unpublished report).

Results reported here suggest that Floy FD-68B T-bar internal anchor tags are suitable for long-term studies of Arctic Grayling, and perhaps also other stream-dwelling species.

Acknowledgments

Information on the two recent recaptures was kindly provided by D. G. Walton, Saskatchewan Parks and Renewable Resources and G. O. Stewart, Envirocon Ltd.

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Received 3 May 1984
Accepted 28 August 1984

News and Comment

New Honorary Members and 1984 Ottawa Field-Naturalists' Club Awards

At the 1985 Soiree two Honorary Memberships were presented, as well as three of the Club's awards: Member of the Year, Service, and Conservation. The Anne Hanes Natural History Award was not presented this year.

Citations were read by President Frank Pope at the Soiree, and are reproduced below. The Club sincerely regrets that four of the five recipients of these honours were unable to be present at the time. The Awards Committee would like once again to express its thanks to Anne Gruchy for her caligraphy on the certificates.

EUGENE G. MUNROE — Honorary Member

The Ottawa Field-Naturalists' Club is pleased to confer Honorary Membership on Dr. Eugene Munroe, FRSC, an internationally-recognized lepidopterist.

Dr. Munroe studied butterflies and moths from his youth, and went on to earn a PhD in Entomology from Cornell University. Prior to his recent retirement, he worked for 30 years as a taxonomist with Agriculture Canada gaining world renown in his field. In recognition of his work, he was made one of the few Honorary Life Members of the Lepidopterists' Society and a Fellow of the Royal Society of Canada.

Dr. Munroe was made Editor-in-Chief of the most ambitious long-term series to date on the moths of North America; several parts of the series have already been issued. In this series, he has also authored the sections on certain moth families, as the acknowledged world authority on those families. As well, his revision of the Swallowtail butterflies published in the 1950s is still the most-quoted source of information on this family.

Dr. Munroe has been a member of our Club since 1963. He is best known by local members for his talks at monthly meetings on butterflies and moths of the Ottawa district. He has also led local excursions, and has been a member of Council.

Despite his busy professional schedule, which has carried him to every continent except Antarctica to collect and study Lepidoptera, he has always made time to pass on his knowledge to amateur and professional alike.

C. STUART HOUSTON — Honorary Member

Honorary Membership is conferred on Dr. Houston in recognition of his many contributions to our literature on birds and mammals, and on conservation. The emphasis in his studies has been on the prairie provinces and the northwest; the total is an important part of our overall Canadian knowledge of nature.

An eminent radiologist, he is Professor and Head of Medical Imaging at the University of Saskatchewan, Saskatoon. In addition to his professional career, he has become well known as an exceptionally active amateur ornithologist and bird-bander. These interests go back 40 years or more; in the early 1940's he banded ducks for Ducks Unlimited in western Canada. Since then his banding of raptors has been prominent. In his 1978 paper in *The Canadian Field-Naturalist* on Great Horned Owls in Saskatchewan, he refers to the banding of 2229 flightless young, over a perod of 30 years. He has also banded other owls, Swainson's Hawks, Ferruginous Hawks, and ospreys. He has studied colonial water birds, banding cormorants, gulls and pelicans. He pioneered banding studies of certain female ducks, and almost all female White-winged Scoters banded in Canada represent his work. The list includes bluebirds, Tree Swallows, Bohemian Waxwings, and other birds at feeders.

In this whole field his reputation is such that professionals seek and use his advice.

Dr. Houston has published in a variety of natural history journals, including *The Canadian Field-Naturalist*, where his name is also frequent in the book review section. He is an authority on the history of natural history investigations, and of the naturalists involved, in central and northwestern Canada. His writing on the subject included four books, the most recent being "Arctic Ordeal: the Journal of John Richardson, Surgeon-Naturalist with Franklin".

Dr. Houston is also well known for his interest in developing other naturalists — in particular, young people — and has been honoured for that in Western Canada. He has been a member of the Ottawa Field-Naturalists' Club since 1943, and we welcome him to the ranks of honorary membership.

FRANK H. BELL — Member of the Year

Frank Bell earned his doctorate in botany from Ohio State University, specializing in plant pathology. He has become well known to many Club members, not only for his interest in wildflowers and weeds, but also for his knowledge of birds. He has

taken part in activities in both these fields for a number of years, leading both regular and special outings. He has been a busy member of the Excursions and Lectures Committee, locating leaders and coordinating resulting data from outings; he is active in the Birds Committee; he is an Associate Editor of *The Shrike*; and while the Botany Group was still active he gave time and expertise to its trips. He was a member of our Council, 1979-1982.

In 1984 Frank stepped in at a time of concern and problems, to help with George McGee's bird classes, and gave talks and led walks for the Bird Interest Group. His efforts were most opportune and valuable, enabling the organization to maintain this activity successfully.

For this extra effort, The Ottawa Field-Naturalists' Club is happy to name Frank Bell its Member of the Year 1984.

DANIEL F. BRUNTON — Service Award

The Service Award was established to recognize those members who are always willing to give, and keep on giving, of their time and energy to help the Club meet its goals. This year's recipient, Dan Brunton, exemplifies this enthusiasm.

A Club member since 1967, Dan has been a member of Council since 1980 and in that period has been Recording Secretary, Vice-President (2 years) and President (1982 and 1983), as well as an active member of the Conservation Committee, Chairman of the Nominating Committee, and now on Finance Committee. He has also been an OFNC representative on the Board of Directors of the Federation of Ontario Naturalists, and as our President he played a major role when the OFNC hosted the 1983 FON Annual Meeting.

Dan has frequently met the media on behalf of the Club, effectively discussing local conservation issues.

He has been a regular contributor to *Trail & Landscape* from its beginning. Through this publication he has provided information to Club members with nearly 60 letters, reports and articles on topics including reptiles, birds, plants, records of past OFNC members, Club activities, and currently his ambitious 3-part work on significant plant records from the Ottawa District. He has also contributed to *The Canadian Field-Naturalist*.

Dan has led excursions, and has been active in organizing birding activities, such as bird counts and the Bird Records Committee.

Thus many Club members have had the opportunity to gain from his expertise on a wide variety of natural history subjects. His energy and enthusiasm have left a lasting impression.

We are pleased to acknowledge his major contributions to the well-being of the Club with presentation of this Service Award.

ROGER TAYLOR — Conservation Award

Roger has played a major role in the fight to save the Carp Hills from development. He participated in the Carp Hills Action Committee which coordinated defense of the area. When regional authorities nevertheless approved the development, his concern led to the Club's Executive Committee formally requesting referral of the matter to the Ontario Municipal Board. Then when this request was rejected he sparked the further considerations leading to our request to the Ontario Supreme Court for a ruling on Regional Council's decision. The legal expenses of this action would have been beyond the normal capability of the Club; however, Roger's presentation to the Planning Committee of the City of Ottawa resulted in a contribution of $20 000 towards these expenses. Subsequently he wrote the deposition that presented our case to the Ontario Supreme Court.

Regardless of the final outcome, it was Roger's vigor, timely reaction, and total commitment that resulted in a clear demonstration that a strong constituency willing to defend significant natural areas does exist. Without his key input, the preliminary vote would have settled the matter.

Roger has been involved in many other conservation matters. He is a director of the Federation of Ontario Naturalists and Chairman of their Conservation Committee, for whose formation he is indeed responsible. His fellow directors have been made aware of our concerns and actions regarding preservation of Alfred Bog, and program reduction in the Canadian Wildlife Service. He presented a brief on behalf of the Club at a hearing on the Canada Water Act. In fact it seems impossible for Roger not to become involved in conservation issues where help is needed.

Roger is one of those people whose interest in nature and concern for its protection is outside his field of specialization. His professional career, with the National Research Council, is in the field of theoretical solid state physics, in which he obtained his doctorate at McMaster University. The Ottawa Field-Naturalists' Club is pleased to honor Dr. Roger Taylor with the 1984 Conservation Award.

W. K. GUMMER

and the members of the
Ottawa Field-Naturalists' Club Awards Committee.

1985 Classification Actions by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC)

COSEWIC in its eight report to the Federal-Provincial Wildlife Conference reported that it had assigned status to 25 species and populations at its annual meeting 2 April 1985.

Committee decisions, based on status reports and agreed status definitions (see *Canadian Field-Naturalist:* F. R. Cook and D. Muir (1984) 98(1): 63-70; D. Muir (1984) 98(2): 262-263) for definitions and previous assignments) were as follows:

RARE

King Rail, *Rallus elegans* — (Ontario) small stable population of limited distribution.

Prairie Warbler, *Dendroica discolor* — (Ontario and occasionally elsewhere) small stable population of limited distribution.

Humpback Whale, *Megaptera novaeangliae* — (North Atlantic population) the small population is stable, there is no evidence of current threats, although past whaling practices had reduced it.

Pugnose Shiner, *Notropis anogenus* — (Ontario) restricted range and numbers.

Silver Chub, *Hybopsis storeriana* — (Ontario and Manitoba) restricted range and numbers.

Brindled Madtom, *Noturus miurus* — (Ontario) restricted range and numbers.

Pugnose Minnow, *Notropis emiliae* — (Ontario) restricted range and numbers.

Bigmouth Shiner, *Notropis dorsalis* — (Manitoba) restricted range and numbers.

Central Stoneroller, *Campostoma anomalum* — (Ontario) restricted range and numbers.

Blackside Topminnow, *Fundulus notatus* — (Ontario) restricted range and numbers.

Soapweed, *Yucca glauca* — (Saskatchewan and Alberta) small numbers, limited to two sites, no known threats.

Dwarf Hackberry, *Celtis tenuifolia* — (Ontario) limited distribution but no known threats.

THREATENED

Humpback Whale, *Megaptera novaeangliae* — (North Pacific population) the small population has limited breeding areas and is threatened by human disturbance. (A re-evaluation — no change in previously assigned status).

Bluehearts, *Buchnera americana* — (Ontario) very restricted and reduced range and habitat, one population extirpated.

ENDANGERED

Piping Plover, *Charadrius melodus* — (Alberta) steadily declining numbers and continuing threats to habitat. A re-evaluation resulting in upgraded status).

Right Whale, *Eubalaena glacialis* — low populations and reproductive rate. (A re-evaluation — no change in status).

Gravel Chub, *Hybopsis x-punctata* — (Ontario) low numbers, no records of occurrence since 1958. (A re-evaluation — no change in status).

Heart-leaved Plantain, *Plantago cordata* — (Ontario) only one remaining site in Canada, species much reduced throughout its entire North American range.

Prickly Pear Cactus, *Opuntia humifusca* — (Eastern population: Ontario) protected plants on a very limited area are still being damaged by trampling, digging and removal.

Water Pennywort, *Hydrocotyle umbellata* — (Nova Scotia) Canadian distribution limited to two localities, one of which is threatened by development.

EXTINCT (Declared on the basis of historical fact without status reports)

Longjaw Cisco, *Coregonus alpenae* — none have been taken since 1960's.

Blue Walleye, *Stizostedion vitreum glaucum* — none have been taken since 1960's.

Sea Mink, *Mustela macrodon* — last seen about 1880.

Labrador Duck, *Camptorhynchus labradorius* — last seen about 1880.

Great Auk, *Pinguinus impennis* — last seen about 1844.

Passenger Pigeon, *Ectopistes migratorius* — last individual died in 1914.

NOT IN ANY CATEGORY (Status reports were reviewed and the species was determined not to be rare, threatened, extirpated, or extinct).

Merlin, *Falco columbarius* — (All provinces and territories) widespread, increasing.

Beluga, *Delphinapterus leucas* — (Beaufort Sea population) healthy stocks, no threats.

WITHDRAWN/DEFERRED (Pending expected new information)

Spotted Owl, *Strix occidentalis*

Redside Dace, *Clinostomus elongatus*

J.A. KEITH, Chairperton
D. MUIR, Secretary

Committee on the Status of Endangered Wildlife in Canada, Ottawa, Ontario K1A 0E7

Announcement: The Biosystematics Research Institute Second Workshop on the Insect Order Hymenoptera

Course Objective — The recognition of about 70 families of Hymenoptera.

Time and Location — 1 to 9 May 1986, in the K. W. Neatby Building on the Central Experimental Farm in Ottawa.

The major hymenopterous groups will be taught by the following B.R.I. taxonomists: H. Goulet (Symphyta), W.R.M. Mason (superfamilies of Hymenoptera, Aculeata), M. Sharkey (Ichnemonoidea, Braconidae), C, Yoshimoto and G. Gibson (Chalcidoidea and Cynipoidea), L. Masner (Proctotrupoidea) and M. Sanborne (Ichneumonidae). Lectures will cover classification, diagnosis, identification, life histories and economic importance of these groups of Hymenoptera.

In a special session, our enthusiastic Dr. Masner will cover modern sampling techniques, the preparation of specimens and the principles of curation.

Classes will begin at 8:00 a.m. and continue until 10:00 p.m. with lunch and supper breaks. Typically, the mornings and afternoons will include lectures and laboratory periods, but the evenings will be reserved entirely for laboratory work (catching up or attention to specific needs). Refreshments will be available.

On the first evening, a complimentary dinner will be provided. This will afford an opportunity to meet the teachers and members of the class as well as other Ottawa entomologists.

Each participant will receive a syllabus containing the lecture material with illustrations, keys and pertinent literature. The syllabus will be forwarded to successful candidates at least one month before the beginning of the workshop.

The course will be limited to 25 applicants and a fee of $300.00 (Canadian funds) will be charged. Candidates will be chosen on a first come first serve basis. (Overall reaction to the first Hymenoptera Workshop was very favorable).

Course application forms and further information may be obtained by contacting: Mike Sarazin, Biosystematics Research Institute, K.W. Neatby Building, Room 3135, C.E.F., Ottawa, Ontario, K1A 0C6, (Tel.: (613) 996-1665).

The Alfred B. Kelly Memorial Fund of the Province of Quebec Society for the Protection of Birds

Annual Research Grants up to $1000 will be available for studies pertaining directly to Quebec ornithology. Applications will be accepted from any interested person regardless of place of residence. Applications must be postmarked by 1 March 1986. Applicants will be notified of the committee's decision before the end of April 1986.

DR. MARIANNE G. AINLEY
P.Q.S.P.B. Research Committee, 4828 Wilson Avenue, Montreal, Quebec H3X 3P2

Amendment to By-laws of The Ottawa Field-Naturalists' Club

(1) The following new By-law was established by a vote of 12 to 1 at the Council meeting of 11 February 1985:

(21) THE OTTAWA FIELD-NATURALISTS' CLUB shall also be known by the style name, OTTAWA FIELD NATURALISTS.

(2) By a motion-in-Council at the Council meeting of 9 December 1985 it was decided to regroup the By-laws in a more logical fashion and renumber them accordingly, with the insertion of a new By-law (10) relating to the duties of the Conservation Committee.

B. J. MARTIN
Recording Secretary

Book Reviews

ZOOLOGY

Pigeons and Doves of the World

By Derek Goodwin. 1983. Third edition. Cornell University Press, Ithaca. 363 pp., illus. + 6 color plates. U.S. $48.50.

As would be expected from the most informed and experienced student of columbids of the world, this edition is as excellent as the two earlier editions. Many species entries have been updated with much of the information having been sent to Goodwin by others. Other changes include three new color plates and text reset into a 2-column page format. The color plates by Robert Gillmor are of rock pigeons, fruit doves of New Guinea, and some endangered island forms. Gillmor's ink drawings of most species are excellent.

Ornithologically, there are no distinctions between pigeons and doves. Pigeon is of Norman-French origin, and dove is of Anglo-Saxon. As with his *Crows of the World*, one of Goodwin's purposes is to indicate what is not known about pigeons and doves.

An introductory 40-page section covers nomenclature, adaptive radiation, plumage and coloration, clutch size and egg color, maintenance behavior, voice, display and social behavior, nesting and parental care, and escape and anti-predator behavior. Almost 300 pages are devoted to species accounts. Species are described; distribution and habitats, feeding and general habits, nesting, voice, and display are discussed; other names are given; and references are provided.

The discussion of *Columba livia* is divided into two accounts, the Rock Pigeon, for the wild forms of the species, and Feral Pigeon. As with many of the species, Goodwin includes interesting behavioral information on the Feral Pigeon although he could have easily gone into greater detail and cited more recent literature on the species. The forms are similar in general shape but Feral Pigeons often have proportionally narrower bodies, longer tails, broader bills, and larger ceres.

The only problem I noted for familiar species is the distribution of the Mourning Dove, which has a more northerly breeding range in Canada than is shown.

All in all, how many books about birds reach their third edition? This certainly says something about its being special. Do not hesitate to buy it if you want solid information on doves and pigeons, with an emphasis on behavior.

NOEL J. CUTRIGHT

Wisconsin Electric Power Company, 231 West Michigan, Milwaukee, Wisconsin 53201

The Canada Goose (*Branta canadensis*) — An Annotated Bibliography

By Scott R. Craven. 1981. U.S. Department of the Interior, Fish and Wildlife Service, Special Scientific Report–Wildlife No. 231. 66 pp. Paper. Free.

This is another useful work in this series. There are now few places where such a work can be published, although with a virtual tide of publications appearing, such works are needed now more than ever before. Despite the headlong rush into computer information retrieval systems, I suspect most people who would be interested in the contents of the publication are still dependent upon printed and published materials. The author intended this to be an aid to anyone (general interest, administrator, manager or researcher) interested, for whatever reason, in the literature of the Canada Goose. He has succeeded in fulfilling that goal.

The alphabetical bibliography contains 646 primary citations, and most are followed by annotations. The subject areas include biology, research, management and taxonomy of the Canada Goose. The list is not complete, omitting incidental references in ornithological texts, bird lists and agency reports. The historical literature is not well covered with only 1% of the citations from pre-1900, 6% are from 1900 to 1930, 5% the 1940's, 18% the 1950's, 40% the 1960's, and 29% are from 1970 through 1977. Only some state and provincial, and federal reports are included, as many were undoubtedly omitted. The interested party might profit by contacting appropriate agencies for additional information. Many agency reports are not of

the quality to appear in reviewed journals, are placed in publication series that do not appear in standard literature reviews, or are internal reports never intended for formal publication but, none-the-less, contain useful information.

The literature search leading to this bibliography included the personal files of the author, Wildlife Review, computer searches of Dissertation Abstracts, Biosis and Agricola, and searches in the libraries of the Department of Wildlife Ecology, University of Wisconsin, Madison, the U.S. Fish and Wildlife Service, Region III, Twin Cities, Minnesota, and the Fish and Wildlife Service, Denver Public Library. The author tried to verify all citations, and those not personally seen are marked. The annotations were taken directly from the above sources (author abstract or summary), abstracted from summaries from the above, taken from Wildlife Review, or if not available, written by the bibliography author. The source of each annotation is indicated. The bibliography ends with a subject index of major topic areas.

STEVEN M. SPEICH

Cascadia Research Collective, 218 1/2 W. 4th Avenue, Olympia, Washington 98501.

Handbook of Animal Radio-Tracking

By L. David Mech. 1983. University of Minnesota Press, Minneapolis. xii + 107 pp. Cloth U.S.$25; paper U.S.$9.95.

During the past two decades, radio-tracking has caused a revolution in the ability of wildlife researchers to study free-ranging animals. Many first-time users have naively considered radio-tracking as a panacea for all. However, as with many new techniques, major problems have arisen with the practical and accurate application of radio-tracking. For example, I found two problems were consistently encountered while training over 50 technicians and biologists to radio-track animals. First, telemetry apprentices were overwhelmed with the technical details and secondly, there was no single basic reference book for a refresher course in the materials and methods of radio-monitoring as commonly practiced today. The *Handbook of Animal Radio-Tracking* should help both these problems. The author, David Mech, has been involved intensively with radio-tracking for over 20 years and is well-qualified to write this handbook.

Mech provides the user with an introduction to parts of a radio-tracking system with sections on transmitters, receivers, and antennae. He discusses problems and considerations that are seldom described in the wildlife literature, such as criteria for choosing a radio frequency, pulse rates, attachment methods, and reliability. Since many of Mech's studies have relied on aerial radio-tracking of elusive and wide-ranging species such as wolves and deer, it is not surprising that his section on aerial tracking is particularly clear, complete, and well-illustrated. A new user should feel reasonably confident to attempt aerial radio-tracking after studying that section. A concise section on homing is also well done. However, the treatment of ground-tracking methods and accuracy may well be insufficient for any more than a starting point for most new radio-trackers. That is largely because those methods invariably require extensive practice and experience before proficiency and accuracy in a variety of circumstances are achieved. Mech's brief account, while perhaps correct, is not a substitute for that experience.

While reviewing this handbook I considered its value to not only new users but also to many of my current staff who are relatively experienced radio-trackers. For them, I found portions of this handbook omitted sufficient detail. State-of-the-art receivers are programmable for automatic scanning of frequencies stored in memory by the user as well as other new features. Many larger projects use such receivers exclusively and their treatment is inconsequential in the handbook. In a similar way many telemetry projects now employ transmitters with activity and mortality sensors almost exclusively. These developments and how to use them effectively are given cursory treatment. Perhaps the text for this handbook was written before widespread use of these. Certainly, the photograph (Figure 8) of the transmitter on p. 16 does not depict state-of-the-art construction methods. Students would have benefitted from two other additions to the handbook. First, a section on the methods of recording, analyzing and describing telemetry data. That methodology has lagged far behind the technological development of equipment, and future radio-tracking students should consider it while designing and conducting projects, not after. Secondly, because radio-tracking is fraught with technical and logistical problems in field applications, it seems that if something can go wrong, it will. Thus, a trouble shooter's appendix or checklist of problems would have greatly enhanced the value of the book. Mech has included

appendices on practice exercises, references, and equipment suppliers. There are relatively few important omissions.

In summary, this handbook should prove valuable to researchers and students wishing to familiarize themselves with the technique. The first sections on radio-tracking history and use will save you days in the library. This small guide is clearly and concisely written and many current users could profit from reading it. I am recommending it as required reading for all radio-tracking staff on our wildlife research projects.

DENNIS R. VOIGT

Ontario Ministry of Natural Resources, Wildlife Branch, Research Section, P.O. Box 50, Maple, Ontario L0J 1E0

The Return of the Sea Eagle

By John A. Loves. 1983. Cambridge University Press, New York. xiii + 227 pp., illus. U.S.$29.95.

The author's primary purpose for writing this book is to tell the story of the re-introduction of White-Tailed Sea Eagles to Scotland. However, he does much more than simply recount the details of an ecological adventure. More than half the book is an account of the biology of eagles in general and the sea eagle in particular.

The author starts by explaining the relationships between eagles and other birds of prey and between the different genera of eagles themselves. He then focuses on the White-Tailed Sea Eagle, its current and past distribution, and its breeding biology and food habits. Although he concentrates on the sea eagle, where appropriate he makes reference to the differences and similarities with other species of eagles.

By the time the chapter entitled: "Persecution and Decline" is reached, the reader will have developed a dismaying sense of foreboding. Indeed, this chapter does not tell a pleasant story. As humans we do not have a lot to be proud of in our treatment of eagles. It is a sad tale; first of the destruction of the adults, then the gathering of eggs and birds to satisfy the Victorian collectors. After the ravages of two world wars the birds still face the scourge of DDT and its kin.

After such a depressing account, the author starts to raise our spirits by explaining what conservation and re-introduction programs are in place. Although we have obviously left it late, it does not appear to be too late to give this magnificent bird the help that it needs.

In the last half of the book, the author explains the re-introduction program to the Island of Rhum in Scotland. I was very impressed with the very careful thought that went into the selection of the re-introduction site, the re-introduction of techniques, and the choice of a source of the eagles. To appreciate how these choices were made, the reader needs a good understanding of the eagle's biology and hence this is a justification for the first half of the book.

The re-introduction program itself is a fascinating tale. With the author's help and a little imagination the reader is transported to the wild woods and crags of Scotland and can feel the wind and hear the sea. The author portrays Rhum as a delightful and romantic isle; a place where eagles ought to be. Into this region he introduces a multitude of young sea eagles and cares for them until they are able to look after themselves. Although the author agonizes over each failure, he is to be congratulated on a very successful operation.

This book also has a bonus. It is peppered throughout with John Love's own excellent drawings. He has depicted fuzzy eaglets, gawky youngsters, and various plumages of adults. The drawings are placed very appropriately throughout the text to illustrate the points being made. The author has also included some black and white photographs which are informative, but not outstanding.

I have one more word of caution. Although an understanding of the biology is necessary to follow the process of the re-introduction, some readers will find the first half of the book a little too detailed. For those with a more professional interest this will not be a problem, indeed they may crave more detail. I was disappointed that there was not a single color illustration of these magnificent birds.

I enjoyed reading this book and would certainly recommend it to those interested in birds and their conservation. For anyone involved in a re-introduction program this book will be useful in providing insights to this process. Bird watchers in general will enjoy the opportunity of learning more about a little known species. Buying books like this one is a measure of support for the people like John Love who dedicate themselves in order that we and the eagles can live in harmony again.

ROY D. JOHN

8 Aurora Crescent, Nepean, Ontario K2G 0Z7

Guide to the Birds of Alaska

By Robert H. Armstrong and editors of "Alaska" magazine. 1983. Alaska Northwest Publishing Company, Anchorage. 332 pp., illus. U.S. $16.95; Canada $19.95.

The author has updated his original 1980 book by adding information on 19 species, raising the total number of birds covered to 405. The book begins with a useful map of the State's biogeographic regions. For the species accounts that follow the author has primarily used photographs to illustrate each bird. Where necessary, additional illustrations are provided by artist John Pitcher. Each illustration is accompanied by a brief description of the bird and its habitat and a status and distribution table.

Although I have very mixed reactions towards this book, I have one clear recommendation. Any birder worth his salt should buy it. It will give many hours of enjoyment to ponder over the photographs of such exotic rarities as Spot-billed Duck, Brown Shrike, Grey Bunting, Bluethroat, Siberian Rubythroat, Siberian Accentor and Red-breasted Flycatcher which do not appear in the other North American field guides. For those who plan to visit Alaska, this book is an obvious must, but even armchair birders will get satisfaction from reading about rarities like those listed above.

I think the real disappointment of this book is that the author lost a marvellous opportunity to fill the information gap on Alaska's rare birds. The common birds are covered by other excellent field guides. In "Birds of Alaska", common and easy to identify species, such as Black-capped Chickadee, fill a whole page while rare and more difficult to identify birds, such as Red-throated Pipit, get only half a page. In addition, all of the descriptions are very short; generally, three of four sentences, with the female of the species only warranting a single line. Winter and immature plumages are poorly covered. I would have preferred that the author concentrate on the Alaska specialities and deal more briefly with the common birds that are so well covered in the continental field guides. The author should also have changed the format of the book to conform with new AOU check list.

The quality control of the colour plates is quite variable in my copy. Some of the photographs are out of register, some have an overall brown hue and many have a blue cast. A few of the photographs are extremely poor. This is surprising as the author has used a wide variety of sources to obtain photographs.

The author is to be congratulated in using western rather than eastern sub-species for his illustrations. For example, the Common Tern illustration (a painting by Pitcher) is black billed and has brown feet, which the author claims is the form normally seen in Alaska. Although not mentioned in the text, I believe the female Yellow Wagtail illustrated is of the Asian sub-species (*Motcilla flava tschutschiansis*).

There are a number of illustrations by John Pitcher. These paintings are excellent, capturing the shape and attitude, as well as the patterning while remaining artistic. I question why the author did not use John Pitcher's talent more often? Why not have him illustrate the White-throated Needle Tail and other species where the photographs are so poor? I think Mr. Pitcher's talents could also have been employed on depicting rarities in female and immature plumages.

This book is well worth buying despite the negative points. Perhaps these comments will help the next revision, which with Alaska's potential could be in just a few years. Finally, I will quote the author's opening line — "Watching birds is fun". For the enthusiastic birder reading this book is fun too.

ROY D. JOHN

8 Aurora Crescent, Nepean, Ontario K2G 0Z7

Maps of Distribution and Abundance of Selected Species of Birds on Uncultivated Native Upland Grasslands and Shrubsteppe in the Northern Great Plains

By Harold A. Kantrud. 1982. United States Fish and Wildlife Service, Jamestown, North Dakota. vi + 31 pp., illus. Free.

Grasslands are a diminishing resource throughout North America, yet there have been few numerical studies of bird species abundance in this biota. Kantrud has made a good start in rectifying this deficiency.

From 1975 through 1978, breeding bird censuses were taken on each of 615 randomly-selected, 65-hectare, grazed grassland plots in the Northern Great Plains from Montana and North Dakota south to the adjoining northern corners of Nebraska and Colorado. For consistency, ungrazed plots and those with obvious evidence of previous cultivation were not censused.

Within each quarter-section plot, the observer used the "hollow square technique" developed by Murray

Speirs and Ronald Orenstein in Ontario. He walked a measured 202 m inside and parallel to each side of the square in turn, listing birds seen or heard within 101 m of this path. Thus 31 hectares were sampled in each plot.

The results are instructively displayed on page-sized maps for the 20 most frequently encountered species, using solid dots, half dots and open dots to differentiate between tercile groups of greatest, average, and least abundance within each species.

These maps offer a number of surprises. Clearly all but the commonest grassland bird species are more sparsely and less regularly distributed throughout their typical habitat than might have been expected from non-numerical studies. Only the Western Meadowlark and Horned Lark were found on half or more of the plots, and the Chestnut-collared Longspur, Lark Bunting, Grasshopper Sparrow, and Vesper Sparrow on between one-third and one-half of the plots.

The next commonest species in terms of numbers of plots mapped, by my count, are the Brewer's Sparrow, seen on 157 of 615 plots, confined to the west; Brown-headed Cowbird, 138, general distribution; Baird's Sparrow, 97, north; Upland Sandpiper, 97, general; McCown's Longspur, 94, west; Brewer's Blackbird, 76, west; Sprague's Pipit, 73, mainly north; Clay-colored Sparrow, 56, northeast; Red-winged Blackbird, 39, surprisingly confined to the Dakotas; Sage Thrasher, 31, west; Long-billed Curlew, 30, northwest and southeast; Bobolink, 25, east; and Common Yellowthroat, 11, north.

Of the species mapped, the Long-billed Curlew is believed to have suffered the greatest decline since human settlers appeared on the plains. Not one of the raptors or corvids was seen often enough to merit mapping.

C. STUART HOUSTON

863 University Drive, Saskatoon, Saskatchewan S7N 0J8

Effects of Soils and Grazing on Breeding Birds of Uncultivated Upland Grasslands of the Northern Great Plains

By Harold A. Kantrud and Russell Kologiski. 1982. Wildlife Research Report 15. United States Fish and Wildlife Service, Washington, D.C. 33 pp. Free.

This report contains the statistical tables from the study reported above and compares distribution of individual species in relation to soil classification and to the degree of grazing. Abundance ranks are given for 20 plant species, chiefly grasses. Soils were divided into warm (with a mean annual temperature above 8° C), and cool (below 8°). Soils were further classified by relative moisture content.

Numerically, the Chestnut-collared Longspur was by far the commonest bird, followed by the Horned Lark and Western Meadowlark.

Kantrud and Kologiski also found that the Savannah Sparrow tended to prefer the cool moist soils and the Bobolink, Brown- headed Cowbird, the moist warm soils. The Red-winged Blackbird and Upland Sandpiper were attracted to moist soils of either temperature. The Horned Lark preferred dry cool soils, the Sage Thrasher the dry warm soils and the McCown's Longspur the dry soils of either temperature.

As regards grazing, the Bobolink, Western Meadowlark, Grasshopper Sparrow, Baird's Sparrow, and Clay- colored Sparrows preferred lightly grazed areas; the Sprague's Pipit and Savannah Sparrow light or moderately grazed areas and the Brewer's Blackbird, moderate to heavily grazed areas. The Mountain Plover, Burrowing Owl and Horned Lark appreciated heavily grazed land best. In addition the Red-winged Blackbird and Clay-colored Sparrow were attracted by the presence of low Snowberry shrubs, while the Brewer's Blackbird liked these and other short shrubs for nesting. Species richness was significantly reduced by heavy grazing.

This report and the previous publication reviewed above, together summarize an important survey, which is bound to be of great interest to those working in adjacent Canadian grasslands.

C. STUART HOUSTON

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Bird Conservation

Edited by Stanley A. Temple. 1983. University of Wisconsin Press, Madison. vii + 148 pp. U.S.$12.95.

This publication, which is put out by the American Section of the International Council For Bird Preservation, is to be the first of an annual series dealing with the preservation of wild birds and their habitat. Noting that it has been widely recognized that exchange of information in the field of bird conservation has often been inadequate and that first hand reports rarely appear in print, *Bird Conservation* seeks to remedy the situation by functioning as a means of dissemination. This first edition is divided into three sections and it is anticipated that future editions will adopt a similar format.

The first section consists of four major reports focussing on birds of prey; future editions will focus on other themes. The reports average about 25 pages in length and the first is on the Peregrine falcon in the eastern United States. The article reports on the progress of the Peregrine reintroduction program and one learns, among other things, that DDE residues are lower and eggshells thicker. The second article, on the Bald Eagle, has a management guideline approach but it too provides factual information. The remaining two articles in the first section are both on the California condor. The first is a study of the species' reproduction which tentatively concludes that the primary problem may be one of mortality rather than reproduction. The final article is an overview of the condor recovery program. Among other things it discusses the controversial radio tracking program and argues that until transmitters are used the factor(s) causing the decline will not be known.

The second section consists of 13 shorter (averaging about two pages long) summaries of recent events in bird conservation. The topics, which range considerably, include conservation activities, legislation, and species and family status reports. The final section is a review of bird conservation literature. This is a 13 page listing by author of works of original information which have appeared, mainly, in the technological literature. There is a very wide range of topics: so much so that if one were looking for a particular topic one would be hard put not to become intrigued by other topics.

Bird Conservation is well written, easy to understand and provides an excellent opportunity to catch up on what is happening in the field of bird conservation. Within its covers it contains numerous tidbits of information of interest to birders in addition to reports of bird conservation developments. Hopefully *Bird Conservation* will inspire other national sections of the ICBP to embark on similar ventures to inform us of what has been happening in their countries. This reviewer heartily recommends *Bird Conservation* to anyone interested in birds or to anyone concerned about conservation. It is a most useful update of what has been happening in a very important field. Next year's edition is eagerly looked forward to.

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BOTANY

Atlantic Wildflowers

By D. Griffin. 1984. Oxford University Press, Toronto. 136 pp., illus. $19.50.

This book contains a collection of 129 quite delightful color photographs of flowers that are found in one or more of the Atlantic Provinces of Newfoundland and Labrador, Nova Scotia, Prince Edward Island, and New Brunswick, but are not unique to those provinces. The pictures are the work of nature photographers Wayne Barrett and Anne MacKay. Each picture together with its common name is on a separate page and is accompanied by a short text under the following headings: Latin Name, Genus, Family, Etymology, Habitat, Range, Longevity, Flowering, Features, Fruit, Height, Ecology, Uses, Horticulture, Similar Species, and References. These are explained in the short introduction. It should be noted however that botanical names do not have to be accepted by an International Botanical Congress as stated by the author. A glossary, a list of selected references and indexes of scientific and common names complete the volume.

One flagrant misidentification has been brought to my attention. The photograph labled *Rubus odoratus* is definitely not that, and more likely should be called *R. acaulis*, which is a dwarf plant.

This book, like many that are coming on the market these days, will make an excellent gift for a naturalist friend whether a resident of the Atlantic provinces or not.

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Wildflowers Across the Prairies — Revised and Expanded

By F.R. Vance, J.R. Jowsey and J.S. McLean. 1984. Western Producer Prairie Books, Saskatoon. 337 pp., illus. $16.95.

The first (1977) edition of this most useful publication was reviewed in this journal (Can. Field-Nat. 91(3): 334. 1977). This revised edition has been enlarged by the addition of some 126 new color photographs and accompanying text plus a key to the families of plants pictured. The introductory materials have been revised somewhat and photo credits are given by each picture rather than the photographers being listed together on a separate page. The old text and line drawings have obviously been offset from a copy of the first edition, much to the detriment of some of the drawings which were criticized previously (e.g. Pale Comandra and Common Hop). In spite of this however the book, like its predecessor, will be welcomed by students, professionals and naturalists, either working in or travelling through the prairie provinces. It will be a most useful companion also to such technical treatments as Boivin's *Flora of the Prairie Provinces*, Moss' *Flora of Alberta* and Scoggan's *Flora of Manitoba* and *Flora of Canada*.

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ENVIRONMENT

Environmentally Significant Areas of the Essex Region

By Michael J. Oldham. 1983. Essex Region Conservation Authority, Essex. viii + 426 pp., illus. + maps. $25.

Many of the counties and regional municipalities in southern Ontario have been studied in an attempt to delineate environmentally sensitive or significant areas (ESAs), but none of those previous studies are as thoroughly documented as this one. This study was clearly well planned, well executed, and the results are well summarized in this report.

Essex County is the most heavily impacted region in Ontario, with less than 3% of its land area remaining under forest cover, and with less than 2.5% of its original wetlands intact. In addition, the remaining areas of long-grass prairie or oak savanna are dwindling. The natural areas still present in the county are the last remaining vestiges of the natural heritage of this southwestern corner of the province, and deserve protection.

The methodology used in this study is outlined thoroughly, and the criteria for selection of ESAs (10) are well defined. Prior to the field phase of this study, 63 candidate sites were identified, in consultation with local naturalists. Each of the 33 designated ESAs selected from this list is described in terms of its general features, impacts upon it, planning considerations, and the criteria it fulfills. However, two of the ESAs are only briefly treated, because they have been well documented elsewhere (Ojibway Prairie Complex and Point Pelee). As a consequence of the geographic location of Essex County within Canada, an interesting situation arose in which virtually every area studied fulfilled one of the ten criteria (the presence of significant species). For this reason, a minimum of two criteria had to be fulfilled in order for an area to be designated as an ESA. Elsewhere in Ontario, it has only been necessary to fulfil one criterion, because no single criterion applied to all of the areas under consideration.

A very important aspect of this study is its well documented nature. A considerable number of experts was consulted and assisted with various aspects of this study. A thorough examination of the literature relating to the natural history of the county is also evident, and where errors have crept into the literature, they are explained and corrected. Most important of all is the fact that the majority of the significant species found in the ESAs are represented by material evidence (specimens or photographs). This lends the important element of credibility to the study, an element that has been deficient or absent in some other ESA studies.

A chapter on conclusions and recommendations summarizes policies that have been used to preserve or direct activities in and around ESAs in other planning jurisdictions in southern Ontario. Additional studies are also recommended to improve and expand upon the level of knowledge of the ESAs, and to assist in the development of effective planning measures for them.

As if the thoroughly documented site descriptions weren't enough, this report concludes with a series of appendices providing preliminary lists of mammals, breeding birds, reptiles, amphibians, butterflies, rare native vascular plants, and bryophytes of Essex County. Thus, this report not only documents signifi-

cant sites, but it provides a large amount of basic data for a wide variety of organisms within the county.

It is inevitable that in a report of this size, some typographical errors will creep in, but these are surprisingly few. The maps and illustrations (photographs and drawings) are generally good, although the body proportions of the White-eyed Vireo (*Vireo griseus*)on page 296 seem to be inaccurate. These trivialities hardly detract from the value of the document, however. I commend Mr. Oldham and the Essex Region Conservation Authority for a job well done, and I hope that they will continue their work in the study and preservation of the last remaining remnants of the natural heritage there.

In my opinion, this document is the epitomy of a good ESA report. Anyone planning ESA studies in the future would do well to use this document as a model. The combination of high quality, competent field work and thorough research are essential to the production of a document that planners will be able to use with confidence.

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Arctic Wildlife

By Monte Hummel. 1984. Key Porter Books, Toronto. 160pp., illus. $29.95.

The Arctic is one of the last remaining wilderness areas on our planet. Like the Antarctic and the oceanic depths, its saving grace has been its inhospitableness to much of Western technology. This grace may soon be at an end. Plans for tanker routes, mines, oil wells, roads, and settlements in the Arctic have been proposed or are already in place. The recent slowing of the pace of Arctic development is likely temporary and, with a change in the economic climate, development will proceed again at a high rate.

Even with limited contact, the record of western culture's impact on arctic fauna over the past three centuries has not been reassuring. Two species of vertebrates, the Eskimo Curlew and the Bowhead Whale, were pushed to the edge of extinction by direct exploitation while two others, the Musk Ox and the Walrus, were hunted to low population levels and have only recently recovered.

A basic question to be answered is "How can a society balance economic exploitation of resources with aesthetics and the preservation of wilderness and biological diversity?" Mr. Hummel does not suggest an answer but he does offer poignant and vivid examples of what could be lost if that question is not resolved. There is a gentle polemical aspect to Monte Hummel's text, that counterpoints the beauty of the photographs presented in "Arctic Wildlife". As executive director of the World Wildlife Fund of Canada, he is in a key position to effect change in Arctic development, at least within North America. Books such as this are one concrete means of effecting change. A public aware of the beauty and biological riches of the North is unlikely to remain complacent to unregulated development there.

Fifteen photographers have contributed photographs for this quarto sized book. Such a diversity of people can offer a breadth of vision perhaps unobtainable by a single artist. However it can also result in a certain uneveness in the images presented and a lack of continuity between the photographs. Inevitably a degree of incompleteness is felt while leafing through this book. It does not have the power and impact that Elliot Porter's volume on the Antarctic has.

There are a few minor points scattered through the text that might be questioned. Walruses probably do not use their tusks for digging up mollusks. Polar Bears are not likely under any greater threat in other portions of the Arctic than in Canada. Although Arctic Ground Squirrels are the only arctic mammals that hibernate in the classical sense, with greatly reduced body temperature, the Brown Bears and Polar Bears of the North certainly undertake periods of prolonged winter dormancy with concomitant fundamental physiological changes. Perhaps the map of the Arctic presented should have been drawn to emphasize the circumpolar nature of the northern biomes. Our maps can and do mould our propensity to think in global terms and international co-operative management is probably the only way to maintain the integrity of the arctic wilderness.

However these are all minor points and do not greatly detract from the book's positive features. I enjoyed reading "Arctic Wildlife" and recommend it for any armchair traveller unfamiliar with the natural beauty of the North American Arctic.

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MISCELLANEOUS

Graduate Research: A Guide for Students in Sciences

By Robert V. Smith. 1984. ISI Press, Philadelphia. xi + 182 pp., illus. Cloth U.S.$21.95; paper U.S.$14.95.

This book deals with the mechanics of graduate study. Hopefully, it would be read after the student has read Jacques Barzun, Clark Kerr, John Gardner, Everett Walters, and such like.

The book spans a long period in the life of a student. The early chapters deal with thinking about graduate study, and would be read most appropriately by high school seniors, university freshmen, or whenever professional careers are being planned. The middle chapters discuss the nature of research, choice of supervisor, and management of time. This section of the book could be read usefully by university students in their third or fourth year. The latter part of the book covers thesis writing, preparation of manuscripts for publication, and finding a job. It is unlikely that graduate students preparing theses or research papers will look there, for example, for advice on English usage or an explanation of editorial proof marks.

The strength of this book is that it covers well the breadth of activities involved in graduate research. It is a good primer for the planning of graduate study. The chapters on the actual mechanics of graduate work are interesting but too superficial to be really operational for the student. For example, in most universities the use of the library is better explained to freshmen and to new graduate students through tours and guide books provided by the university. Hopefully students will have conducted literature searches and written research reports many times before entering graduate study. For advice on writing and thesis preparation, graduate students would be better advised to consult Fowler's Modern English Usage, AIBS Style Manual, CP Style Book, Campbell's Form Book of Thesis Writing, etc.

The book is written for the life sciences and from an American perceptive. Thus the library orientation is Library of Congress, and abstracting services are all U.S.; Canadian ones like CISTI are not identified. Similarly the chapter on making grant applications is uniquely American.

In summary, Graduate Research is comprehensive, well written, and most appropriate for high school seniors and university freshmen. Copies should be available in high school and university libraries. The book will be less useful to graduate students per se, as they will be familiar already with most of the information in this book.

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Conservation and Evolution

By O.H. Frankel and Michael E. Soulé. 1981. Cambridge University Press, Cambridge. viii + 327 pp.

This book might better have been titled "Consequences of Population Genetics for Conservation." Its concern is the loss of genetic variation in species whose numbers or diversity are being reduced by human activities: relict populations in 'nature reserves,' captives bred in zoos or botanic gardens, and localized breeds (land races) of domestic species overwhelmed by cosmopolitan breeds. The population genetics are routine formulae in their usual habitat — discussions of the evolution of abundant species — but here, in the context of captive propagation and shrinking and disrupted habitats, they are startling and disturbing. Small (< 1000 breeding adults) populations just don't retain genetic variation very well, and quickly drift towards homozygous fixation of one set of alleles, which, if compatible leaves a population without much ability to evolve, but more likely includes enough minor deleterious alleles to make extinction inevitable. There are ways to stir the gene pool to slow the loss of variability by the design of reserves and control of population structure. The ideas outlined in this book should be understood by anyone managing or defending any population whose numbers are likely to drop below several thousands.

If any fault is to be found with the authors' view of the world it is perhaps too binary. Habitat is considered to be either intact/preserved or degraded/developed, and species are visualized as existing only on islands of preserved habitat. This is doubtless truer between the tropics than it is under the shadow of Pleistocene ice, where nothing has been in place for very long, and where many species still have continental gene pools, But if our species plans to amount to more than a Holocene plutonium anomaly we are going to have to learn to manage this planet so that our use of the land allows large populations of other

species to go about their business in a full range of extensive habitats, not confined to tiny islands in an ocean of cultivated spruce, soya beans, and sugar cane.

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Perspectives on Evolution

Edited by Roger Milkman. 1982. Sinauer, Sunderland, Massachusetts. xi+241 pp. Cloth U.S.$27.50; paper U.S.$14.95.

In a celebration of the centennial of the *Origin of Species,* one of the many fathers of Neodarwinism traced evolutionary theory since 1859, finding a dramatic change every 20 years. When asked what, since Neodarwinism had had its 20 years, would replace it, he could foresee neither replacement nor change. Twenty years later cladists, immunologists, neutralists, and creationists proclaim its overthrow. How much must this old theory change, now that allele frequencies, the chemistry of genetics, the timing and location of geological events, the fitness of alternative life histories, and the methods of taxonomy, once matters of speculation, have become matters of measurement? The present symposium volume, dedicated to Ernst Mayr, seeks an answer to this question.

In the first chapter G.L. Stebbins formalizes the robustness of evolutionary theory: its laws are not the brittle hypotheses of hypothetico-deductive science, but are broad "modal themes" of the study of myriad independent lineages that, interacting with physical laws, geologic change, and each other, produce the complexity of the living world. He hopes that the use of modal themes can reduce controversy between positions that are extremes of continua.

A.R. Templeton models punctuated equilibrium with the shifting balance model of allelic selection. In a changed environment, with small populations and changed mating patterns, radically different alleles are favoured, and may settle down to stasis as a new species when alleles at other loci adjust to the major allele. S.J. Gould suggests that if species remain essentially unchanged for a long life after sudden speciation, then much overall change within higher taxa may be due to factors that cause "birth" or "death" bias among species, rather than a net within-species adaptation. This was suggested by the punctuated equilibrium model, but does not depend on it. Puncutated equilibrium describes morphologic stasis in fossil lineages (where biological species may be spuriously lumped or split), but if speciation takes $< 1\%$ of a species lifespan, then $< 2\%$ of modern species should participate in taxonomic ambiguity — and the figure is probably ten times that.

"Phylogeny," by R.K. Selander, is about phylogenies constructed from molecular data. The stories are interesting, but suffer from the idea that "for phylogeny what we have always wanted is the structure of the genes themselves — the nucleotide sequence" (p. 33). What we have "always wanted" is phyletic history, and nucleotide sequences are only one kind of data that can be analysed to reveal part of that history. In "The genetic structure of species" F.J. Ayala rehearses the great intrapopulation allelic variation revealed by electrophoresis. "He writes this paper every year," and there is more of the flavour of a paean than a critique here.

R. Milkman and G. Bush, considering the organization of genetic variation in the context of allelic fitness and speciation, respectively, agree in the conclusion that alleles in gene pools are not coadapted, but are compatible, and that we do now know how one compatible gene pool changes into another by speciation. In chapters that are catalogues of kinds of data and adaptations B.V. Plapp reviews the biochemical and phyletic "Origins of protein structure and function" and I.P. Crawford surveys "Nucleotide sequences and bacterial evolution."

In two concluding chapters T. Hunkapiller, H. Huang, L. Hood, and J.H. Campbell assess the impact of these new ideas. They find in molecular genetics a combination of hierarchy and anarchy: new functions arise in the reuse of existing structures, and are regulated by diverse feedback with both the environment and other genetic information. It is probably no accident that this sounds like morphologic evolution and morphogenesis; natural selection doubtless produces similar patterns of change at any level. Indeed, it is in levels of selection above and below the individual and locus that this volume documents changes in Neodarwinism. These are technical, not philosophical, advances. Darwinism, the modal theme of Descent with Modification by Natural Selection, is independent of the mechanisms of genetics: it requires heritable variation, and asserts that adaptive change results from natural selection and that nonadaptive change results from something else. The view of Hunkapiller, et al., that Neodarwinism "is essentially a marriage of Mendelian genetics and classic Darwinian selection" (p. 164) ignores the match-making role of species-level taxonomy and geographic variation: the polytypic species was the basis of gradualism.

Campbell claims that "Neodarwinism [denys] the biological system any causal role in its evolution [because] the gene pool does not evolve in that active sense, it 'gets evolved' by the environment" (p. 191), and that modern genetics has found self-reference and directed modification among genes. In place of Neodarwinian coadapted alleles we have coadapted loci and parts of loci, which is less net gain in self-reference than Campbell notices.

This volume is one useful perspective on changes in evolutionary theory, but largely ignores the problems of species-level systematics. Because (as in cosmology) distance is an analog of time, these problems will continue to be a major testing ground of evolutionary theories.

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Arctic Ordeal: The Journal of John Richardson, Surgeon-Naturalist with Franklin, 1820-1822

Edited by C. Stuart Houston. 1984. McGill-Queen's University Press, Kingston and Montreal. xix + 348 pp. illus. $24.95.

John Richardson, surgeon-naturalist to the first two of John Franklin's expeditions to explore the Arctic coast of North America, has long been known for his multi-volume *Fauna Boreali Americana*, based on zoological observations and collections made during 1819-22 and 1825-27. The Scottish-born Richardson was a good observer, well-trained in several branches of natural history, including botany, geology, ichthyology, lichenology, and mammalogy. Although a beginning ornithologist during his first arctic journey of 1819-22, by the time he returned to North America in 1825, he became a good bird man.

Much of our current knowledge of these famous expeditions had been derived from Franklin's narratives of his two journeys to the "shores of the Polar Sea," which include, to varying degrees, the accounts of his fellow officers. Because Franklin lost his own early journals, he made use of the notes and observations of Richardson, Robert Hood, and George Back. Additional information concerning the first journey came to light with the 1974 publication of Hood's journal and painting. *To the Arctic by Canoe* was also edited by Houston. Now, a decade later, John Richardson's journals have been brought to us by the same meticulous researcher, who not only transcribed and annotated the journals, but retraced much of the route the explorers took. H.A. Hochbaum, long known for his evocative paintings of Prairie marshland and waterfowl, had also followed the same route. His black and white illustrations provide a wonderful feel for the vast expanse and stark beauty of the northern landscape, its plants and animals.

Arctic Ordeal is organized in three major parts: the body of the journal, Introduction and Conclusion by Houston, and six appendices. There are also eight detailed maps, of different sections of the route covered by the exploring party between September 1820 to December 1821. Tables on such diverse subjects as the dates and principal locations of the exploring party, corrected daily distances and courses, food consumption, and rocks mentioned by Richardson, form useful addenda.

Houston's "Introduction" gives the general background of the journey and includes short biographical sketches of the principal members of the party. It sets the scene for the reading of the journal, which incidentally begins three weeks before Hood's journal ends.

The carefully annotated journal entries are of varying lengths. Some are brief comments, such as "A goose seen today," written on 21 May 1821, or "On the 13th there was a heavy gale of wind, and we passed the day by the fire," entered on 13 October 1821. Others provide detailed descriptions of people and events, or observations of weather, distances, temperatures, lichens, and animals.

Houston's "Commentary" provides added insight into various aspects of the journal and indeed the expedition itself. It discusses Richardson's medical contributions and actions, the food consumption of the exploring party, "tribulations and rescue," cannibalism, and murder charges. There is a separate entry for Pierre St. Germain, the successful hunter and most indispensable man of the expedition, and finally Richardson's achievements are considered and evaluated. These sections are a testimony to Dr. Houston's knowledge and careful research, as are the notes, and the appendices on Richardson's bird and mammals observations, and botanical and ichthyological contributions. Additionally J. W. Thompson evaluates Richardson's contribution to lichenology, and W. O. Kupsch discusses Richardson's geological field work.

This is an important contribution to the history of Arctic explorations and natural history in Canada. It is well designed, beautifully illustrated, and a must for every naturalist's bookshelf.

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NEW TITLES

Zoology

The amphibian ear. 1985. By Ernest Glen Wever. Princeton University Press, Princeton. c520 pp., illus. U.S.$65.

Animal thinking. 1984. By Donald R. Griffin. Harvard University Press, Cambridge. ix + 237 pp., illus. U.S.$17.50.

Birding in Ohio. 1983. By Tom Thomson. Indiana University Press, Bloomington. 256 pp., illus. U.S.$15.

Birds of Indiana. 1984. By Russell E. Mumford and Charles E. Keller. Indiana University Press, Bloomington. 400 pp., illus. U.S.$49.95.

***Birds of Nahanni National Park.** 1985. Edited by George Scotter. Saskatchewan Natural History Society, Saskatoon. 741 pp. $7.

***Butterflies east of the Great Plains: an illustrated natural history.** 1984. By P.A. Opler and G.O. Krizek. Johns Hopkins University Press, Baltimore. xvii + 294 pp., illus. U.S.$49.50.

†**Butterflies of Europe, volume 1: concise bibliography.** 1985. Edited by Otakar Kudrna. AULA-Verlag Gmblt., Wiesbaden, Germany. c450 pp., illus. cDM 248.

Corals and coral reefs of the Galapagos Islands. 1984. By Peter Glynn and Gerard M. Wellington, with an annotated list by John W. Wells. University of California Press, Berkeley. xvi + 330 pp., illus. U.S.$45.

The corals of Hong Kong. 1984. By P.J.B. Scott. Hong Kong University Press, Hong Kong. viii + 112 pp., illus. HK$85.

***Current ornithology, volume 2.** 1985. Edited by Richard F. Johnston. Plenum, New York. xiv + 364 pp., illus. U.S.$39.50.

The dawn of animal life: a biohistorical study. 1984. By Martin F. Glaessner. Cambridge University Press, New York. xii + 244 pp., illus. U.S.$49.50.

***The ecological implications of body size.** 1983. By Robert Henry Peters. Cambridge University Press, New York. xii + 329 pp., illus. U.S.$32.50.

***Effects of soils and grazing on breeding birds of uncultivated upland grasslands of the northern Great Plains.** 1982. By Harold A. Kantrud and Russell Kologiski. Wildlife Research Report 215. United States Fish and Wildlife Service, Washington, D.C. 33 pp. Free.

The encyclopedia of mammals. 1984. Edited by David Macdonald. Facts on File, New York. xvi + 896 pp., illus. + appendices. U.S. $45.

Evolution of fish species. 1984. Edited by Anthony A. Echelle and Irv Kornfield. From a symposium, Tallahassee, Florida, June 1983. University of Maine at Orono Press, Orono, Maine. x + 257 pp., illus. Cloth U.S.$28.95; paper U.S.$20.95.

Fishery management. 1984. By J.L. McHugh. Springer-Verlag, New York. viii + 207 pp., illus. U.S.$15.

***Fishes of the north-eastern Atlantic and the Mediterranean/Poissons de l'Atlantique du nord-est et de la Méditerranée.** 1984. Edited byy P. J. P. Whitehead, M.-L. Bauchot, J.-C. Hureau, J. Nielsen, and E. Tortonese. Unesco Press, Paris. 510 pp., illus. 250 FF.

Fish physiology, volume 10: gills, part A: anatomy, gas transfer, and acid-base regulation; and **part B: ion and water transfer.** 1984. Edited by W.S. Hoar and D.J. Randall. Academic Press, Orlando. 480 pp. and 440 pp. U.S.$59 and U.S.$69.

The grey whale, *Eschrichtius robustus*. 1984. Edited by Mary Lou Jones, Steven L. Swartz, and Stephen Leatherwood. Academic Press, Orlando. 624 pp., illus. U.S.$75.

Handbook of the birds of India and Pakistan, volume 4: frogmouths to pittas. 1984. By Salim Ali and S. Dillon Ripley. Second edition. Oxford University Press, New York. xvi + 267 pp., illus. + plates. U.S.$37.50.

†**Handbuch der Reptilien und Amphibien Europas, volume 2/1: Echsen II (Lacerta).** 1984. Edited by Wolfgang Bohme. AULA-Verlag GmbH, Wiesbaden, Germany. 416 pp., illus. DM216.

Insects of the world. 1984. By Anthony Wootton. Facts on File, New York. 224 pp., illus. U.S.$17.95.

The Oxford book of British bird names. 1984. By W.B. Lockwood. Oxford University Press, New York. x + 174 pp. U.S.$16.95.

***Polar bear: life history and known distribution of polar bear in the Northwest Territories up to 1981.** 1984. By D.R. Urquhart and R.E. Schweinsburg. Northwest Territories Natural Resources, Yellowknife. 70 pp., illus. $6.

***Rare, endangered, and extinct fishes in Canada.** 1985. By Don E. McAllister, Brad J. Parker, and Paul M. McKee. Syllogeus 54. National Museum of Natural Sciences, Ottawa. 192 pp., illus. Free.

***Reproductive decisions: an economic analysis of Gelada baboon social strategies.** 1985. By R.I.M. Dunbar. Princeton University Press, Princeton. x + 265 pp., illus. Cloth U.S.$40; paper U.S.$14.50.

Seabird energetics. 1984. Edited by G. Causey Whittow and Herman Rahn. Proceedings of a symposium, Honolulu, August 1983. Plenum, New York. c290 pp. U.S.$55.

Shorebirds, volume 1: breeding behavior and populations; and volume 2: migration and foraging behavior. 1984. Edited by Joanna Burger and Bori L. Olla. Plenum, New York. xvi + 437 pp., illus. and xiv + 329 pp., illus. U.S.$59.50 and U.S.$49.50.

Size and scaling in primate biology. 1984. Edited by William L. Jungers. Plenum, New York. c475 pp. U.S.$69.50.

The whale watcher's handbook. 1984. By Erich Hoyt. Madison Press, Garden City, New York. 208 pp., illus. U.S.$12.95.

White-tailed deer: ecology and management. 1984. Edited by Lowell K. Halls. Stackpole, Harrisburg, Pennsylvania. xxvi + 871 pp., illus. + plates. U.S.$39.95.

Zoological philosophy: an exposition with regard to the natural history of animals. 1984. By J.B. Lamarck. Translated from French by Hugh Elliot. University of Chicago Press, Chicago. lxvi + 458 pp. Cloth U.S.$30; paper U.S.$15.

Botany

Botany in the field: an introduction to plant communities for the amateur naturalist. 1984. By Jane Scott. Prentice-Hall, Englewood Cliffs, New Jersey. viii + 163 pp., illus. Cloth U.S.$16.95; paper U.S.$8.95.

A colour atlas of flowering trees and shrubs. 1982. Edited by V. Csapody and I. Toth. Akademia; Kiado, Budapest. 312 pp., illus. U.S.$44.

Eating wild plants. 1984. By Kim Williams. Mountain Press, Missoula, Montana. ix + 140 pp., illus. U.S.$9.95.

Flooding and plant growth. 1984. Edited by T.T. Kozlowski. Academic Press, Orlando. xiv + 358 pp., illus. U.S.$55.

***The flora of Manitoulin Island and the adjacent islands of Lake Huron, Georgian Bay and the North Channel.** 1984. By J.K. Morton and Joan M. Venn. Second revised edition. Biology Series No. 28. Biology Department, University of Waterloo, Waterloo. 181 pp., illus. plus 106 pp. maps. $20 (illustrations available separately at $4 per set).

From flower to fruit. 1984. By Anne Opelia Dowden. Crowell, New York. 56 pp., illus. U.S.$13.50.

Growing wildflowers: a gardener's guide. 1984. By Marie Sperka. x + 277 pp., illus. U.S.$9.95.

Light and the flowering process. 1984. Edited by Daphne Vince-Prue, Bryan Thomas, and K.E. Cockshulli. Proceedings of a symposium, Littlehampton, England, September 1983. Academic Press, Orlando. 328 pp. U.S.$27.50.

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Honey-bees. 1984. By Graham Tarrant. Pop-up Book. Putnam's, New York. 9 pp., illus. U.S.$6.95.

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Content

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The **Council of Biology Editors Style Manual**, 4th edition (1978) available from the American Institute of Biological Sciences, is recommended as a guide to contributors. **Webster's New International Dictionary** and le **Grand Larousse Encyclopédique** are the authorities for spelling.

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